DOCUMENT RESUME

ED 220 282 SE 038 807

AUTHOR	Maines, David R.; And Others
TITLE	Social Processes of Sex Differentiation in Mathematics. Final Report to the National Institute of Education. "Role Modeling Processes and Educational Inequity for Graduate and Undergraduate Students in Mathematics."
INSTITUTION	Northwestern Univ., Evanston, Ill. Program on Women.
SPONS AGENCY	National Inst. of Education (ED), Washington, DC.
PUB DATE	Dec 81
GRANT	NIE-G-79-0114
NOTE	274p.
EDRS PRICE	MF01/PC11 Plus Postage.
DESCRIPTORS	*College Mathematics; College Students; Educational Research; Females; *Graduate Students; Higher Education; Learning Theories; Mathematics Education; *Sex Differences; *Sex Role; *Undergraduate Students
IDENTIFIERS	*Mathematics Education Research

ABSTRACT

The purpose of this study was to determine social processes of sex differentiation for undergraduate and graduate students in mathematics and how those processes relate to educational inequity. To gather data relevant to those processes, 168 in-depth interviews were conducted with male and female students majoring in mathematics and with faculty at three Chicago area universities. The strength of the study rests in (1) the focus on females who have "survived" the high school attrition process and who are able mathematicians upon entry into college, (2) the pervasive focus on social processes in which educational experiences are embedded, and (3) the systematic sex-comparative research design. Data analysis was qualitative in nature, and the data are presented in the form of (1) simple distributions of responses suitable for determining overall patterns and (2) an analysis of direct quotes to determine personal meanings. An explanatory schema is presented regarding sex-differentiation which was induced from the data. That schema hinges on processes of self-selection, differential association, sex variation in the specificity of support networks, narrow versus diffuse perceptions of the world, and differences in opportunism and instrumentality. Little evidence of systematic or overt sex discrimination was found in the universities. (Author)

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SOCIAL PROCESSES OF SEX DIFFERENTIATION IN MATHEMATICS

Final Report to the National Institute of Education

"Role Modeling Processes and Educational Inequity
for Graduate and Undergraduate Students
in Mathematics"

NIE-G-79-0114, 1979-1981

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December, 1981

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ABSTRACT

The purpose of this study was to determine social processes of sex differentiation for undergraduate and graduate students in mathematics and how those processes relate to educational inequity. To gather data relevant to those processes, 168 in-depth interviews were conducted with male and female students majoring in mathematics and with faculty at three Chicago area universities. The strength of the study rests in (1) the focus on females who have "survived" the high school attrition process and who are able mathematicians upon entry into college, (2) the pervasive focus on social processes in which educational experiences are embedded, and (3) the systematic sex-comparative research design. Data collection focused on various aspects of the influence process, including family and educational influences before college, the role modeling process, and family and career aspirations. Data analysis was qualitative in nature, and the data are presented in the form of (1) simple distributions of responses suitable for determining overall patterns and (2) an analysis of direct quotes to determine personal meanings. An explanatory schema is presented regarding sex-differentiation which was induced from the data. That schema hinges on processes of self-selection, differential association, sex variation in the specificity of support networks, narrow vs diffuse perceptions of the world, and differences in opportunism and instrumentality. Little evidence of systematic or overt sex discrimination was found in the universities.

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ACKNOWLEDGEMENTS

Many individuals made substantial contributions to the study. Not the least of which to be gratefully acknowledged are the administrators, faculty, and students who cooperated during the collection of the data.

Arlene Kaplan Daniels encouraged the senior author to write the proposal and, along with Joy Charlton, made a number of substantive contributions to its revision. Bari Watkins, Director of the Program on Women, not only was an able administrator but an insightful colleague throughout the study. Neal Rubin, Wendy Goldberg, and Joy Charlton were outstanding interviewers. Much of the success of the study is due to the high quality of interviews they conducted. In addition, they each invested their own time in discussing numerous theoretical and methodological issues raised by the data. Professors Judith Sally and Donald Saari of Northwestern's Department of Mathematics, who served as consultants, were instrumental in the early phase of the research. Finally, Susan St. Louis and Paula Thomas were diligent office workers who, as much as anyone, kept things going.

CHAPTER I

INTRODUCTION

Very few women in the United States who pursue careers outside the home do so in the field of mathematics. A host of cultural, social, interpersonal and, as some have tried to argue, biological factors have deflected them away from such careers. These factors have existed for years, and regardless of the rhetoric of hope expressed during recent times, they continue to have their effects. The proportion of PhD's in mathematics who are women has remained at 10% or less for most of this century.

The large scale research projects conducted during the past two decades on sex differences in mathematics have established that junior high and high school are critical turning points. Females shy away from the masculine domain of mathematics presumably because it conflicts with their emergent identities of being feminine and because they relate less well than males to logic and deductive thinking. While the flavor of some of these notions are passe, they have received empirical support in studies that underscore the importance of social processes, including the role of significant others, support systems, career goals, and self-evaluation, in sex differentiation in mathematics.

In an effort to promote research on these social processes, the Social Process/ Women's Research Program of the National Institute of Education solicited research proposals during 1978-79. Our study was funded to examine the importance of role modeling as it occurs among males and females in mathematics, and to assess the relative function of role modeling for reducing the sex-based inequities in mathematics.

On the assumption that issues of inequity involve long term and ongoing processes, our research utilized the life history approach. Accordingly, we became interested not only in role modeling but in any pattern of participation throughout a person's life, such as family and peer involvement, that could be reagrded as contribuitng to that inequity. As a consequence, our study became one addressing those processes that did or did not feed into patterns of sex differentiation.

Chapter II of this report describes the conceptual underpinnings, research questions, and a review of related leterature. Chapter III describes the methodological procedures we used to gather information. Chapter IV, V, and VI present findings concerning undergraduate majors in mathematics, graduate students in mathematics, and faculty, respectively. Chapter VII consists of an enumeration of our major findings. Supplementary tables and interview schedules are appended.

CHAPTER II

LITERATURE REVIEW, THEORETICAL ISSUES, AND ANALYTICAL PURPOSES

Recent findings of sex discrimination and other social processes that create or perpetuate patterns of sex differentiation throughout academic institutions have increased the concern for the place of women in higher education (Astin, 1969; Rossi and Calderwood, 1973; Feldman, 1974). A number of studies have focused on educational barriers, ranging from admissions and finance policies to sex role constraints (Roby, 1973; Furniss and Graham, 1974; McGuignan, 1976). Others have focused on the problems women face who have sought to enter disciplines traditionally populated by men. These investigations have included studies of medicine (Bowers, 1966), anthropology (Fischer and Golde, 1968), and science and engineering (Mattfeld and Van Aken, 1965).

One of the disciplines especially difficult for women to enter and continue through to completion of the advanced degree is mathematics. For over a half century, the proportion of women receiving doctorates in mathematics has remained constant at about six percent (Rossi and Calderwood, 1973: 257), although in recent years it has been increasing slightly. Research has shown that the sources of the differences contributing to such a low proportion are predominately, if not exclusively, social in nature. The studies by Earnest (1976) conclude that there is nothing intrinsic in the subject that makes it more appealing to one sex or another. Yet there are sex-linked differentials that begin to appear as early as junior high school. A substantial body of findings (reviewed by Fox, Fennema, and Sherman in Women in Mathematics: Research Perspectives for Change, 1977) show that performance and participation differentials are systematically linked to sex role socialization regarding femininity, career, family, and achievemnet. The interpenetration of family, education, and peer influences in the process leads to a pervasive and circular process that encompasses most of the educational life span (Fox,1976). Females avoid mathematics in high school and thus are less prepared for mathematics in college, and therefore are selected out of occupational areas that involve mathematics. Also, they are less likely to envision mathematics as relevant for their lives. The increased attrition rate of females out of mathematics at the secondary school level and the future consequences of that attritition are quite well documented.

Research on patterns and processes of participation of women in mathematics at the university level is much more scarce than that at the secondary school level. Case material, such as Pour-El's (1974) vivid account of her experiences as a graduate student and faculty, however, suggest that sex-related problems continue, even for those females who are talented and trained in mathematics. A few studies specify some of those problems. Patterson and Sells (1973: 86) show that the attrition rate of female graduate students, controlling for ability, is almost twice that of male graduate students and that being married accounts for some of that differential. Role conflict between domestic and professional obligations appears to be the relevant process underlying this factor. Other factors involve reports that women are more likely to experience emotional strain as well as pressure from their spouse and, in addition, to feel that the professors in their department do not take them as seriously as students (Creager, 1971). They appear less likely, as well, to engage in forms of anticipatory socialization and informal peer networks that are critical in graduate school training (Feldman, 1973). What scanty literature there is, in other words, suggests strongly that men feel and experience much less life conflict and are the most adjusted of all. The existing literature relevant to issues of patterns of participation of women in mathematics at the university level thus provides a few clues regarding key variables, but little information regarding the social processes in which the educational careers of female students are embedded and which influence the trajectories of those careers exists.

Our research during the past two years has been devoted precisely to uncovering those processes. The theoretical position we took at the outset of the research was that those processes centered around role modeling. Using the central assumption of symbolic interactionism (Blumer, 1969), we proposed that much of the circularity described by Fox (1976) could be accounted for in structural terms, insofar as there were few females in mathematics, and in processual terms, insofar as role modeling is a functional process that enhances the completion of advanced education. The locus of functionality, we argued, rests in the modeling of lifestyles. If the traditional schisms between home and work are a major source of difficulty for female studnets, then having female faculty in their field who successfully combine the two could provide examples for them to emulate in terms of their own lives. Support for this theoretical proposition came from Roby (1972), who identified role modeling as a problem, and from Bucher and Stelling's (1977) research on professional socialization, which showed that the modal role modeling process was what they called the "partial model" -- the modeling of traits into a composite model. The significant traits for female students, then, would have to include the lifestyles of female faculty.

While our analysis will retain the symbolic interactionist thrust and some focus on the role modeling process, our data cannot support the theoretical proposition just described. In short, it is a simple-minded explanation. Rather, we will discuss the "influence process," in which role modeling is only a part, as a type of socialization process. This discussion will dovetail with one focusing on processes of self-selection and on long term personal and collective understandings about the nature of the future. The structure of our analysis, therefore, will be lodged in three processual elements: (1) the influence process, including family, educational, and peer networks, as a moving social organizational context in which mathematics as a meaningful activity is assessed, (2) self-self-selection, including personal ambition, careerism, and action, and (3) long term definitions of the person's projection of himself or herself into the future, including determination, sacrifice, and a form of tunnel vision. This analysis places explanatory emphasis both on the individuals who are being educated (ie., decision making, values, personal goals, hard work) and on the system of influences (professors, high school teachers, parents, boyfriends and girlfriends, peers) representing the contexts and shapers of choice. Our data do not allow us to treat these elements independently of one another.

CHAPTER III

RESEARCH METHODS AND PROCEDURES

This chapter will describe in some detail the procedures we used for drawing a sample of respondents, how we collected our data, and the procedures we used for organizing those data into forms suitable for analysis.

Sampling

Our sample of undergraduate and graduate students was drawn from three schools -- University of Illinois at Chicago Circle (UICC), Northwestern University (NU), and the University of Chicago (UC). The faculty, male and female, were sampled from those three universities and from DePaul University.

A list of declared undergraduate majors was obtained from each department. The lists were generally up-to-date, but the UICC and UC lists contained a number of inaccuracies. The UICC list was the most inaccurate. From the lists we attempted to obtain a proportional sample of students by year in school and area of concentration within mathematics. The department at UICC includes statistics, math education, pure math, applied math, and computer science. The UC math department houses pure math and applied math, while NU's department houses only pure math. We therefore attempted to sample each school according to the make-up of the department, and we believe our samples reflect each department's specific characteristics. In addition, the undergraduate lists, hence our sample, were skewed toward juniors and seniors. Few sophomores, and even fewer freshmen, declare majors.

Additionally, the sex distribution was skewed. At UICC there were a large number of declared math majors who are female; however, there were few at UC and NU. We interviewed approximately 15% of the female math majors at UICC (N = 20), approximately 90% at NU (N = 20), and all the female math majors at UC (N = 10). (The complete sample distributions are given on the following page). The inaccuracy of the lists, coupled with the uneven distributions, prevented randomized and matched sampling. However, since our study is one which was to uncover those social processes encasing and involved in mathematics education, the non-randomized, non-matched sampling poses no theoretical or methodological problems. We were able to study the processes of males and females at three schools, and comparisons are not a problem.

The interviewer or principal investigator contacted the students who were selected in the samples. While there were some rejections, the overall level of cooperation was high. During the initial contact the student's status within the department was confirmed and an interview time was scheduled. The undergraduates were interviewed either at their place of residence or the interviewer's office. The respondents were told we had acquired their names and phone numbers from the department, we were from Northwestern University, that the study was funded by the National Institute of Education, that we were interested in the experiences they had involving mathematics, that the interview would last 60-90 minutes, and that they were guaranteed anonimity. Most students quickly consented to the interview.

The interviewers were all graduate students in the social sciences who had had experiences in qualitative research techniques. Each interviewer was trained, one-to-one, by the principal investigator.

Sample Distributions

	Males			Females		
	North-western	University of Chicago	Illinois-Chicago Circle	North-western	University of Chicago	Illinois-Chicago Circle
Undergraduates						
Freshman	0	0	1	0	0	3
Sophomore	1	2	1	1	2	3
Junior	7	6	2	8	5	3
Senior	11	12	8	11	3	11
Totals	19	20	12	20	10	20
Graduate Students	8	10	7	2	5	10
Faculty (other Faculty N = 3)*	4	6	3	2	2	5

Totals By Sex	Males	Females	Grand Totals
Undergraduates	51	50	101
Graduate Students	25	17	42
Faculty	14	11	25
Totals	90	78	168

* Other Faculty - one male, two females

In addition, the interviewers were monitored as they went along. That is, the principal investigator would listen to interviews and go over the strong and weak points with each interviewer. All interviews were conducted on a same-sex basis. That is, males interviewed male respondents and females interviewed female respondents. This was done to minimize socially accepted responses, increase the experiential bond between respondent and interviewer, and allow the interviewer to probe hard and cut through rhetoric.

The graduate students within our sample were acquired in a fashion similar to that of the undergraduate students. We received a list from each department with students' names and phone numbers. Again the lists were generally up-to-date and accurate, and we found this to be the case at NU and UC, but the UICC list was again very problematic. The problem with NU's graduate studnets involved the females. The lists were given to us during the first year of the study, but the interviews did not begin until the fall of the second year. Before the female graduate students at NU could be interviewed, 75% dropped out of the graduate program. What we did was interview all the female graduate students at UC (N = 5) and at NU (N = 2) and approximately 20% of them at UICC (N = 10). The interviews with graduate students were done either at their office, their home, or at the interviewer's office. Again, the interviewer or principal investigator contacted those who were selected as part of the sample. The graduate students were told that their departments had furnished us with names and phone numbers. We explained who we were and what the research project involved. In addition, we confirmed their status within the graduate program. Graduate programs, like undergraduate programs, vary with departments. In addition, schools and departments tend to attract particular types of students. For example, UICC students tend to be older and have had more on-the-job experience. Our sample reflects the uniqueness of each school and department. Since we are examining social processes, these distributions enhance our findings. The level of cooperation among graduate students was high and most rejections were due to time constraints, although some believed they had nothing to say and few thought that the study was a waste of time. The interviewers who handled the graduate students were themselves graduate students in the social sciences. These interviews also were same-sexed.

The faculty were harder to sample and impossible to match. There are two female math professors at NU; we interviewed both of them. There are no full-time, tenure track female math faculty members at UC. There were, however, two Dickson Instructors. These Instructorships are two year appointments given to persons with the PhD. We interviewed both of these women. At UICC we were able to interview approximately 33% of the female faculty (N = 5). When we realized that we had so few female faculty (N = 9), we decided to sample DePaul University's math faculty. We were able to interview 33% of the female faculty (N = 2) and one male faculty member. Again, since we are interested in social processes, the inclusion of the three DePaul University faculty members enhanced rather than confused our inquiry. Except for females at NU and UC, we were able to sample from every instructional level.

Each department provided us with a roster of faculty members with home and office phone numbers. A member of the research team contacted the faculty member and explained the research project. Most people were willing to be interviewed, although the response rate was somewhat lower than those for our student samples. Faculty interviews were done in the office of the faculty member. In addition to interviewing a sample of faculty members, the chairs at UICC, NU, and UC were interviewed.

We pretested the interview guide with five 90-minute interviews, and it was altered several times based upon the pre-tests, the interviewers' suggestions, the input of the consultants and interviews with the consultants (Professors Judith Sally and Donald Saari of Northwestern's Department of Mathematics). The principal investigator and the consultants worked together early in the project so as to include those dimensions relevant to our study.

Data Collection

Our research problem focused on processes surrounding becoming a mathematician and doing mathematics; thus the interview guide was constructed to provide a life history of the respondents. The undergraduate interview questions were clustered around the following dimensions: the respondent's special interests and/or contacts with mathematics before high school, high school experiences, college experiences, role models and influence persons, and aspirations which encompass home life and career objectives. See Appendix A for the undergraduate interview schedule. The interview schedules were different for undergraduate males and females in so far as the questions were gender specified. Otherwise, the questions and broad topic clusters were uniform.

The graduate student dimensions were: pre-college educational experiences, college experiences, graduate school experiences, role models and influence persons, and aspirations which encompass home life and career objectives. See Appendix B for the graduate interview schedules. Again the interview schedules for graduate males and females were different in so far as the questions were gender specified. Otherwise the questions and broad topic clusters were uniform for males and females.

The faculty interview schedules were organized according to the following dimensions: The respondent's life history of their career and personal life and its management, experiences during high school and undergraduate years, experiences during graduate school years, experiences as a faculty mamber, and some final questions on the singular-collective dimension of doing math, the essential qualities of the successful mathematician and advice that they as faculty members give to females who are having career-family management troubles. See Appendix C for the faculty interview schedules. The interview guides for male and female faculty were identical except for the gender specified questions.

The data were gathered through in-depth, semi-structured interviews. All interviews were taped and the tape recorder was never turned off during the interview process. The interviews were conducted in accordance with an interview guide. The interviewers were told to be sure they included all the questions/categories found on the interview guide. For the most part this occurred. In addition, all interviewers were told to follow-up on the respondent's ideas, concepts, and experiences. The interviews include stories and elaborations upon the original questions. Thus, while the interview guide provided comparability among respondents, it was flexible and allowed for respondents to expound upon our original questions. During the period of data collection, ideas and concepts that were originally included in the interview schedule or excluded from it were amended. For example, the aesthetic pleasure of mathematics came up during two or three interviews with faculty and advanced graduate students. After examining the interviews and discussing it with others in the field, we amended the interview guide so as to include this topic. In other words, there was a constant monitoring of the completed interviews so that amendments, inclusions, and exclusions of topics form the interview guide was possible. Through this procedure the research team was confident in the fit of data and theoretical constructs. This data collection procedure is described more fully in Glaser and Strauss (1967) and Denzin (1970).

Data Organization

At the start of all interviews an appropriate face sheet was filled out which included relevant background and demographic information. The tape recorded interviews were transcribed by professional transcribers. There was an original and carbon copy for each interview. After being transcribed, each interview was given a code number and an additional copy of the interview was xeroxed. The code number represented the school, year in school, and gender of the respondent; in addition, each interview was assigned a triple digit number which allowed the transcribed interviews to be placed in consecutive order. For example, CC2F003 represents a UICC female sophmore whose interview is file number three. The interview pages were numbered consecutively to include all 168 interviews. The total number of pages of interview data exceeds eight thousand pages. All transcribed interviews were logged with code number and page number into a master log book.

The interviews were coded in two phases. The first phase was for distributional characteristics of the data; the second phase gave the research team insights and understandings into the meanings of the responses. To insure maximum intercoder reliability only the principal investigator and two other persons coded the data. The coders were graduate students in the social sciences with qualitative research experience. They were trained by the principal investigator. They coded a number of interviews together and the principal investigator spot-checked the coding for accuracy. The principal investigator and the coders developed a codebook for undergraduate interviews, graduate interviews, and faculty interviews. These codebooks gave criteria by which the transcribed interviews could be synopsized for distributional coding, yet maintain the richness and quality found in open-ended interviews. The data were coded onto large accountant sheets according to school and gender. For example, all the female undergraduates at NU are coded on the same sheet. The interview questions were listed along the left side of the coding sheets and the code numbers were listed across the top. Each cell contained a response as well as the page number(s) where that response was found. The page numbers were included so that the raw data could easily be retrieved. This phase of coding allowed the research team efficient access to the data, yet was also a shorthand version of the transcripts that provided accurate distribution of responses.

The second phase of coding involved working directly from transcripts. Again this coding was done by the principal investigotor and two coders so as to insure maximum inter-coder reliability. The coders were graduate students in the social sciences with qualitative research experience. This phase was designed to allow the stories and answers of respondents to be grouped together according to the topic being addressed. That is, each of the categories in this phase were arrived at inductively. Examples of the categories are: high school interests, stereotypes about difficulties with mathematics, female professors in college, ambiguities about graduate school, earliest interest in mathematics, male reactions to females in math, stereotypes of mathematicians, friends affecting choice of major, persons who influenced you to go into math. Based upon the first phase coding, reading the transcripts and trying to group topics together, the principal investigator and coders arrived at categories which best reflected what was being said in the interviews. The categories and the questions being asked did not have perfect correspondence. Rather, these inductively derived categories reflected topics, issues, and experiences that were common to the respondents. A master list of categories and topics was constructed, and each interview was analyzed and cut-up according to the categories addressed. Each segment of the interview was coded and placed in a folder with quotes addressing the topic from the other interviews. For example, the undergraduates' discussions of pre-high school experiences/ interests in math are all in the same folder. What this phase allows is the retrieving of data on a topical basis.

The way the data are organized provide the research team with the following tools: a log book with code numbers and page numbers of the transcripts, a folder with two copies of a complete interview, code sheets which allow eyeballing of distributions of responses, and folders of quotes which all address the same topic. In this way the research team can use the inductively determined data, the deductively examined data, and the complete interviews in order to address the issues of sex differentiation in the process of mathematics education.

Chapters IV, V, and VI present analyses of data pertaining to the undergraduates, the graduates students, and the faculty, respectively. Data are presented in two forms. Frequency distributions are used to show overall patterns of responses. Although this is a low level statistic, it is sufficient to identify those responses that are important for an analysis of sex differentiation. The second form of data is direct quotes from the interviews. These quotes serve several functions. They keep us in touch with the basic information of the study, they are a reminder that these are live and breathing human beings we are talking about, they add flesh and substance to the frequency distributions, and they allow us to assess the meaning of responses. The interweave of two forms of data provide the analyst both with patterns and depth in the analysis.

CHAPTER IV

ANALYSIS OF THE DATA - I:
UNDERGRADUATE STUDENTS

This chapter presents our findings from interviews with undergraduate students majoring in mathematics. The data are organized longitudinally, and include sections on high school experiences (this section also presents some findings from interviews with graduate students), experiences during college, significant others and role modeling, and career and family aspirations. These sections follow the life history format used in the interviews.

Sampling Characteristics

Undergraduate males typically come from families in which the father was employed in a professional or business occupation (62%). Undergraduate females' fathers were evenly split between professional/ business and blue collor occupations (43% each category). Also, half of the mothers of these students worked full time, although a very low percentage (6%) were in professional/ business occupations (Table D-1). Parents of these students were fairly well educated. Forty-four percent of males' fathers and 53% of their mothers had at least a college education, while 46% of females' fathers and 29% of mothers were so educated. As an aggregate, males come from families where parents were about equally educated and females come from families in which fathers were more likely to have a higher education than the mother. For both males and females, however, fathers out distanced mothers in proportion of professional degrees (Table D-2).

Average age for all students was twenty-one, although there was a greater age range (17-36) for students at UICC and there was a higher proportion of older students and married students in that department.

High School Years

While every respondent in our sample had developed an interest in math by the time they were in junior high school, it is the undergraduate females who appear to have had the earliest interst. For the undergraduates, 42% of the males and 76% of the females indicate elementary school or earlier, and 56% of the graduate males and 47% of the graduate females do so. Surprisingly, graduate students appear to have developed their interest somewhat later than undergraduates, although this difference is most pronounced for females (Table D-4).

During high school, as expected, these students were more interested in math and science than other academic fields (Table D-5). Table 1, however, shows differences in areas of primary interest. Those differences appear between undergraduate and graduate males, in which graduate males were twice as likely to be interested in academics (59% vs 24%). Undergraduate males appear as very balanced among the various categories of activities, but the females and graduate student males tended to emphasize academics. These differences suggest the possibility of a self-selection process based on interest which applies primarily for those males who eventually pursue math at the graduate level.

No differences were found in the proportion of students who were on advanced math tracks during high school -- roughly three quarters of the sample (Table D-6). Nor are there any major differences in the

Table 1

Students' Assessments of Main Interest During High School

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 73)	(N = 59)	(N = 25)	(N = 35)
Academics	24	47	59	52
Athletics	33	15	18	16
Extra-curricular	20	22	12	20
Social Life	8	9	11	12
Art/Music	15	7	0	0
	100	100	100	100

Table 2

Distribution of Students Encouraged in Math in High School

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 47)	(N = 46)	(N = 25)	(N = 16)
Yes	40	67	64	50
No	60	33	36	50
	100	100	100	100

Distribution of Students Discouraged in Math in High School

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 25)	(N = 27)	(N = 20)	(N = 11)
Yes	20	41	10	0
No	80	59	90	100
	100	100	100	100

Table 3

Career Plans In High School

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 46)	(N = 47)	(N = 25)	(N = 20)
Undecided	13	13	16	15
Go to College	9	6	12	15
Math Professor	10	0	32	10
High School Math Teacher	4	2	4	35
Professor Other Than Math	2	9	0	5
Something in Math	0	9	16	0
Science/ Engineering	29	20	12	5
Computer Work	0	0	0	5
Business	11	6	0	0
Medicine	13	13	4	0
Law	9	4	0	5
Other Professional	0	6	0	0
Clerical	0	6	0	0
Art/Music	0	6	0	0
Other	0	0	4	5
	100	100	100	100

proportion of those who had female math or science teachers in high school -- a majority in all cases (Table D-7). Undergraduate females, as shown in Table 2, were both more likely than males to have been encouraged to pursue their interests in math (67% vs 40%) and more likely to have been discouraged (41% vs 20%). These data indicate that while females were not without positive encouragement, a portion of them were recieving mixed messages, ie., encouragement and discouragement .

Table 3 shows graduates' and undergraduates' career plans when they were in high school. As expected, there is a wide range of categories of responses and those responses fall largely (over two-thirds) into professional or business fields. A few noteworthy differences stick out: a higher proportion of undergraduates than graduate students, for example, wanted to go into science/engineering amd medicine. Relevant to our inquiry into sex-differences in math education, however, we note that four times as many males as females wanted to be math professors and four times as many females as males wanted to be high school teachers. These differences are the most profound among the graduate students, suggesting that males enter school with a more professionally focused orientation. Note the following quotes form the interviews relevant to these differences. First the males:

> I definitely wanted to do research in mathematics. You know, definitely. Basically, there's very few places that support research and one of the most common places that supports research is the universities, where teaching is

> your responsibility. That's more or less the way that I viewed it then and that's basically the way I view it now. I mean, I'm teaching a class during this summer and I taught last summer, of course, being a TA all the time. And I don't mind teaching. At times it's quite enjoyable, but it's certainly not my primary interest, which is definitely research. You know, no doubt about that (Northwestern male, 1412-1413).

> Well, I always naturally assumed that I would go on to college. And beyond that, I think I strongly assumed that I would go on to do graduate work. And, I imagine if I had to pick out something it might have been something like I'm doing now. But, I wasn't interested in thinking that far into the future. I figure that would become clear. I guess, I was just interested in mathematics, so... (Northwestern male, 1898).

Females, however, preferred teaching.

> (When you were in high school, was there any point when it was clear that you decided that you wanted to teach math?) I actually think that decision was made sometime during my senior year, at high school, because when I walked in my freshman year and sat down, I almost missed registration. I wasn't real good at filling out forms and different things .... I'm still not (chuckles) but, somebody who was

> going to Circle went to my Dad's school and said, "Oh, they are registering at Circle today" and my father said, "Oh, they are? My daughter's supposed to go," so he gave me a call. I ran down there and just sat with one of the people in the math department. I just figured I wanted math, so I went to math. But actually, within the beginning of my freshman year in college, I had four years already planned out as a math major. You know what, though, you know what could have been? -- well I don't know if that has anything to do with math, but when I was a junior and senior in high school, they had the Illinois Teacher's Scholarships being offered, and with that, if you promised to get your degree in the teaching field and make a commitment to teach two years in Illinois, once you get your degree, they would pay tuition, or a certain amount, in a state school, so that was one reason why I came here. And I was pretty sure I wanted to go into teaching so I went into that. But I still think my senior year I started toying with the idea, "Well should I go into biology?" It was either biology or that type of science or math. I toyed with teaching art for awhile and toyed with teaching P.E. (Circle female, 6568-6569).

We wish to emphasize the quantative differences here, since they are rather astounding: 48% of the graduate student males compared to 10% of the graduate females mentioned mathematics, exclusive of high school teaching. Making this difference more astounding are the

Table 4

Students' Responses to: "What Did Your Parents Want You to Be?"

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 42)	(N = 51)	(N = 25)	(N = 20)
Whatever I Wanted	65	52	52	17
To Go To College	0	0	4	30
Professor	2	2	16	0
Medicine	14	15	16	4
Law	5	1	0	0
Business	12	12	4	0
High School Teacher	0	0	0	27
Other Professional	0	6	8	9
Something in Math	2	2	0	0
Clerical	0	6	0	0
Discouraged Career	0	4	0	13
	100	100	100	100

Table 5

Students' Assessments of Major Factors for Choice of Undergraduate College

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 80)	(N = 94)	(N = 39)	(N = 31)
Academics	38	22	10	6
Overall Academic Reputation of College	10	0	26	6
Financial Aid	10	6	3	26
Inexpensive	5	9	4	3
Proximity	12	15	23	13
Far From Home	6	3	0	20
Nice Campus	3	5	0	10
Size	3	5	0	10
Only School Accepted By	3	0	0	0
Sports	1	1	0	0
Relatives Attended	1	5	9	3
Friends There	1	0	9	0

Table 5

Students' Assessments of Major Factors for Choice of Undergraduate College (continued)

	Undergraduate Student		Graduate Student	
	Males (N = 80)	Females (N = 94)	Males (N = 39)	Females (N = 31)
Boyfriend/ Girlfriend There	1	9	0	0
Geographical Area	5	6	9	0
Counselor's Influence	1	3	0	3
Church Affiliated	0	0	7	0
Other	0	12	0	0
	100	100	100	100

data presented in Table 4. If we combine "whatever I wanted" and "to go to college", we see few differences in parental influence, other than a slight edge to males' choices being more supported. What stands our in our minds in terms of Table 3, however, is the fact that parents of graduate student males specifically supported their choices of professor (16%) while parents of graduate student females specifically supported the choice of high school teacher (27%). These differences suggest early career choice differences not only in student preferences but in the context of support in which those choices are made.

Table 5 indicates that undergraduate males are twice as likely as females to designate academic excellence as the reason for selecting a particular college to attend (48% vs 22%), while graduate males are three times as likely (36% vs 12%). The only other major differences rest in the reasons given for graduate females. Twenty-six percent versus 6% designated financial aid, while 20% versus 0% designated "far from home". Some females seemed to want to get away from their parents.

> My dad did not want me to work with my hands because he had to and he's had a hard life. My mother never had a chance to go to college. So they wanted me to go to college. But they did not have anything particular in mind for me (Did they want you to have a career?) That wasn't necessary. (Why did you go to Allegheny?) I wanted to go to a school that was farther than a three hour drive from my home town so my parents couldn't visit. I

wanted a coed school, a liberal arts school, and some place where they offered degrees in teaching. Allegheny had a five year program where the fifth year you spent in the Cleveland public school system; it's very close to Cleveland. Your senior year, you student taught for one quarter in Cleveland. Then, your fifth year you taught the whole year and came back and did some work toward a masters degree. So it was a five years masters program. When I entered Allegheny, the Cleveland public schools were still a good system and it seemed like a real good place to be going. It was a good program. It was exactly what I wanted to be -- a teacher. You got a BS in whatever your field was instead of having your degree in education. That seemed more legitimate to me (Chicago female, 3605).

I had a scholarship that I had to use in New York. Of the schools that I was interested in, that was the one in New York that I was most interested in. I knew that they had a good math and computer science program and it was far away from home. There's a SUNY campus right across the river from where we lived I could have gone there. But I decided that I wanted to go away. (Circle female, 3252).

The emerging pattern of males making choices (and being supported

Table 6

Students' Responses to: "Why Did You Choose a Major in Math?"

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 47)	(N = 44)	(N = 23)	(N = 16)
Valued Math	64	41	74	31
As Background	6	5	17	13
Circumstance	6	18	9	44
Influential Professor	4	9	0	0
Avoid Other Areas	16	17	0	0
Easy Major	4	5	0	6
To be Math Teacher	0	5	0	6
	100	100	100	100

in them) on the basis of their interests in math and on academic excellence is elaborated by Table 6. It shows males more likely to have chosen to major in math because of their positive valuation of the activity of doing math: 64% versus 41% for undergraduates and 74% versus 31% for graduate students. (The 31% for graduate females is surprisingly low, considering they are now pursuing graduate degrees in the area). Females, however, give reasons that can only be categorized a "circumstances". A couple of examples of these circumstances are: an accumulation of credits that made their decision to major in math an expedient one, and not doing well in science. The following quotes, however, provide a closer look at the bases of these decisions.

> Well I got into my first chemistry course here. I knew I was learning a lot but I had nothing to show for it. With competition the way it is here I was standing in the middle of the class and getting C's, and I knew that wouldn't get me any place. I couldn't get into dental school with that. Plus the fact that I was working very hard and not really liking it a lot. So I went through a period of about two quarters where I didn't know what I was doing or where I was going to be and finally decided to go back to what I'd always liked to do which was math (Northwestern female, 579).

> I kind of backed into math. Until my senior year, I was a

double major. In fact, my advisors up until my senior year were English faculty. I had advanced placement credit, so they sent me to the math department. The English people were blind to what was going on over there. They said, "Math's a good interest. If you don't get a job in English, you can always do something in math. So, go take all the courses over in that department that you like." So I did that. I focused mostly on English, though. I completed a lot of English requirements. But, the math teachers I had were focusing me on math major requirements as well--up until it was time to write my senior paper. I had to choose between the two or write two papers because I was a double major. So, I completed all the requirements for both. Except that I did not write a senior paper for English. I did one for math because it seemed more creative. (Chicago female, 3606).

Basically, my decision was tied up with my decision to major in French. In the course of my first year, I took calculus because I assumed that it was just the intelligent thing to take, and I was doing very well, and then I discovered that there is a program for people in the sciences to go and spend a year or a semester in France studying at one of the universities. I found that fascinating and thought it was a wonderful thing to do. It never came off, though, and I ended up not doing that, but my freshman year I applied for both the math and the french major. I thought if I'm going to do this, I have to

> accellerate my program in math here because I need some more math courses under my belt before I go away my junior year. The Mundeline calculus sequence, I should explain, is a five quarter sequence. It moves fairly slowly, so what I did was to work ahead to let me finish off the calculus sequence over the summer before my sophomore year. They let me get away with that. Essentially, they let me get away with murder, which is one of the great assets of that school. So, I essentially decided to major in math as opposed to majoring in one of the sciences because I knew that I was good in math and that it would give me a hook in the program in France (Chicago female, 3988-3989).

The pre-college pattern that emerges from these data is one emphasizing an early substantive interest in mathematics for males, in which they seek to express that interest through aspiring to be a math professor or "doing something in math." This interest and focused attention is not challenged by others. With this framework and focus in mind, they select colleges on the basis of academic excellence, and they major in math because that is where their interest and passion lies. We propose a self-selecting process in which those who enter graduate school are those who have had a life-long interest in the field. Females, on the other hand, develop very early interest in math, but our findings (not shown) indicate that less than 5% of those early interest females designate a career in math by the time they are in high school. Obviously, the interest in the subject matter is there and they are well trained for it, as shown by the high percentage on advanced math tracks and by the fact of their college major in mathematics. However, even for this select group (compared to all females, many of whom drop out of math during high school), there is not the focused interest in mathematics, the overall orientation toward academics at the college level, and the positive value of mathematics, when compared to the males. Their interest in mathematics receives suppprt and encouragement, but that support is more diffuse than that of the males, and in a sizeable percentage of all cases, they choose and are encouraged to express their interest in mathematics through secondary education.

College Experiences Related to Being a Math Major

Since this study maintains a focus not only on processes of sex-differentiation but on the elements of educational inequity, we will examine the experiences of undergraduate math majors from the standpoint of difficulties and problems they face.

Table 7 shows the distribution of problems faced by males and by females. Overwhelmingly, males state that the major problem is the work of mathematics itself (64%). Note how males refer to this problem.

> It's very frustrating. It's frustrating not to be able to understand something new, and that's something you have to deal with all the time. So, I think that is the biggest problem. There can be a lot of frustration (Chicago male, 3476).

> Let's say you have a surface area. You have an ellipse. You have this thing and have to figure it out. When you get right down to it, take it apart, what you have there are one

Table 7

Undergraduate Responses to Perceived Problems in Mathematics for Their Sex

	Males (N = 36)	Females (N = 52)
No Problems	8	10
Math Subject Matter	64	4
Interpersonal Relations	11	17
Gender Stereotypes	3	31
Math Stereotypes	6	17
Career Problems	0	6
	100	100

> or two things. They might be using some ways you didn't think of. It's like you have this richly carved chest. You open it up and there is a hard boiled egg, an old rusty nail, and a thimble. That's kind of disappointing. The idea here is that you know how long it is and what the axis is. I felt that was a little difficult for me. You come right down to it, and parts of math are very work-a-day. Sit down and learn a definition (Chicago male, 3102).

> I would have to say, and this is not infallable, but I would have to say the abstractions. Taking the subject seriously and really grasping the concepts. You know that is really not that difficult if you are really in math. I can't see a barrier for someone interested in mathematics. (Chicago Circle male, 7616).

Females, on the other hand, overwhelmingly identify problems in the area of social relationships (65%), with half of those (31%) specifically mentioning stereotypes pertaining to females. Note what they say about their problems.

> Well, it's getting better, but since there aren't as many females in math, I think you don't get peer support, because I think people tend to give peer support to people of their own sex. I think that since it is considered a traditionally male type of field that there is resistance, just like you know there's resistance to women in any traditionally male field. (Circle female, 3709).

> Maybe it's just dealing with that stereotype, but I don't have any problem because I don't see it as a problem. I don't feel it is a threat to being feminine and I don't feel I can be a woman and I can be in math and the two don't conflict, but maybe some women feel they do conflict. Maybe in high school they feel that math doesn't go with them and they push it away and say I have had enough math to get into college and I want to go into communications or I want to go into theatre and math just doesn't have anything to do with it. It will make me more of an outgoing person and I don't look at it that way. I don't know that I can seperate the two parts of my life or--I don't know--but I don't look at it as a possibility. Maybe it's for some girls. They don't feel that they should go into other things that will be easier for them and they can use their charm or whatever to get ahead in communications and things like that. It's more of a skill; well, math is a skill, too, but they don't have the talent to seperate being feminine from their major because they are all tied up together. Their being attractive helps them in talking to people and being in public relations whereas math and public relations don't really go together. (Northwestern female, 3801-3802).

Nearly two-thirds of both males and females feel that it is harder for females to succeed in the field of mathematics (Table 8). A female senior at the University of Chicago gave the following account.

Table 8

Undergraduate Responses to: "Is it Harder for Females to Succeed in Math?"

	Males (N = 43)	Females (N = 41)
Yes	64	61
No	36	39
	100	100

> They are not as bright as the guys (laughter). I don't know, the guys seem to have started earlier than women, so they kind of have an advantage. They get into that stuff in high school, and so I feel like all the guys that are my age are years ahead of me in math. So, that's the boundary. (315).

A female student at Northwestern gave another account.

> (In what respects is it harder for females in math to make it?) When I think about it, the question you asked me before, math prof's probably do have the same type of feelings about women. Because that's one of the reasons that I would think a woman would have a rough time, just because she wouldn't be looked at as having the desire to do as much or go as far, because she was going to be a family person--the stereotype. A lot of math professors I've known have been like my grandparents generation. And I see it in my own grandparents. That's the type of stereotype that they were brought up with, and that was the role of women at that point. Granted there are a lot more younger people in the math field, and I would think that it is changing, but it takes a number of years. I get very frustrated about it. But I realize there's not a whole lot I can do about it. I fight it. It could backfire as well as doing any good. If you fight it, they're going to say, you know, you're just getting hyper about something--"the truth hurts" type of thing. Ever heard that? If you get upset about something then you know it's true. And it can work

> in that respect as well as changing it, but I'm kind of banking on the fact that time will have a lot to do with it. Given enough time. (591-592).

Males give somewhat different reasons.

> I don't know. Maybe it's just because there aren't many women. I don't know. You have to understand, but to just sit there and do math is a kind of frustrating thing. It can be. It's real frustrating work because it they give you a problem, that's basically what you do. You go to class and they teach you about some principle. They teach you a few theorems. And then they give you a bunch of problems. And, if you don't know how to do a problem, you know--usually there is a certain way of looking at it or something, or some little trick. And if you figure that out, then you are all set. Then you just write it down. Like in business, I'm sure you write reports and stuff. In math, you don't ever have to do that. The finished product is probably smaller, just in terms of the number of pages. But in order to get that, you have to see something. To figure something out. And, if you can't, it's real frustrating. And, maybe, you know, women cry more than men do. And I can see a lot of times where I just want to sit there and cry almost, because I couldn't get something. Maybe that's what drives women out, because they don't want to cry all the time about their work. I don't know. I think women are taken very seriously. There are plenty of

> women mathematicians. They are outnumbered by men mathematicians, you know, probably ten to one, maybe more. I'm sure you know those numbers. But the ones that are doing the work are taken perfectly seriously. (Chicago male, 4482-4483).

> I suppose they don't have as much of a precedent. I am sure the statistics are simply overwhelming in the favor of men becoming math majors and getting math degrees. But that is kind of a chicken and egg kind of concept. I don't know. Maybe women are more prone to interpretative subjects, such that they can make up their own mind about the way they want to work instead of having to fit into an already prepackaged set of guidelines. Philosophy strikes me as being much less rigid because you can rationalize anything that you make up your mind to be. And you really can't do that with math. If you want to get the answers, there are a certain amount of steps you have to follow. You can't re-interpret the rules or anything. Not and get the correct answer. If women are actually more emotional, and I guess my experience is that they are, or at least show it more, then they are more likely to get frustrated or allow themselves to become frustrated, and try to re-interpret the rules. Try to get outside the guidelines. It certainly sounds easier to me to be able to make it up as you go along. (Circle male, 6664-6665).

Whatever the reasons--ability, traditional expectations, stereotyping, less "feel" for math--there is fairly wide consensus among the students that females have a harder time making it in mathematics.

Table 9, however, indicates that only a small proportion of students think that there is any overt resistance to women in math. Both males and females, regardless of that low percentage, though, can come up with stories about various forms of resistance.

> It's a subtle thing. This teacher I was talking about was very personable. Every once in a while we'd get him away from mathematics because it was sort of boring. Anyway, he was an older man. We'd ask him about mathematics and his experiences in it in general. He talked about this one woman who was very bright and had contributed a lot, and then he made this remark that she was ugly as hell. I think that was a little bias coming out. The class really didn't respond to that. This one particular class had, I think, one woman in it. And she was nervous about it. She grimaced. As soon as he said that, I turned around and looked to see her reaction, and she grimaced. (Circle male, 95-96).

> I guess there's some kind of prevailing attitude of people about men generally being better in math. Apart from that, it's just a matter of students' attitudes. It's hard to say what the teachers' attitudes are. I never get to deal with them on a personal level anyway. Hopefully, they're going to dismiss their personal feelings from their professional responsibilities. There's no real resistance. Just something like understanding and sympathy, or they don't do quite so well. But I don't know

Table 9

Distribution of Undergraduates' Perception of Resistance to Women in Math

	Males (N = 45)	Females (N = 49)
Resistance is Present	24	14
Resistance is not Present	76	86
	100	100

if they'd get discouragement or anything like that. See what I mean? They probably get resistance from their parents, but that has nothing to do with the fact that I am a math major or anything. That has to do with the fact that I deal with people in the real world. (Circle male, 7693).

Not from professors. Maybe from some of the other students that might be in the classroom. You know, they really don't come out and say it, but it's a kind of feeling you get. For instance, I just went through two equation classes that I have this quarter. I think that they're really disco classes. Twelve people in it and only two girls--me and this other girl. And most of the people in there are physics majors and they've had lots of this stuff before. And the teacher will say, well, you know, "how many of you have seen this type of problem before" or something. And all the people in physics have seen it before in application, but I hadn't. And, you know, most everybody just sits there and kind of nods their head, and the teacher says, like, "well, ok, I won't go into it." It's too much detail. And, I'm like, well wait, I've never seen it before. In that sense, I feel kind of like a minority of the class because I haven't had all the physics that the rest of these people have had. He'll go through it, but he doesn't really go through it as well as if everyone in the class had said they hadn't seen this before. But that's about it. But as far as the professors, no, I don't feel.... It's different, though. I can kind of tell when a teacher will, say, hand me back an exam and they'll pass me and say they have two girls or whatever, you know, they just kind of look at you and say, like, "which one of you is which?" The rest, it seems like when you're handing back exams they know the boys names better than the girls names. I mean, they don't have to read off the names, but they'll just kind of hand it to the guys, so as far as the girls go, "which one of you is Linda and which one of you is Debbie?" (Chicago female, 1334-1335).

Usually I will get as much as I can out of a course regardless of who's teaching it. But, this past quarter, it was so frustrating to be in this class--there were only about eight people and I was the only woman. And this teacher was actually picking on me. Whenever anyone would ask a question he would answer it. You know, no big deal. But whenever I would ask a question, he would put me down three or four times, or he would refuse to answer my question. He said, "I don't want to answer that" or some such thing. Or, he said, "It's not important." And it wasn't that he didn't know how to answer the question, because he was not shy about saying he didn't know something. But it was something that he knew the answer to, and for some reason didn't want to talk about it. He didn't want to spend the precious class time to answer my question. And, in fact, one incident that I remember particularly well, because it was very unreasonable. The class was called Topology, but it was really set theory and metrics. But he was lecturing away and proving some theorems, and the ideas

> were clear to me until a certain point. And then I could tell that he was about to go on to a new topic, but the end of the proof didn't make sense to me. And I didn't know exactly why it didn't make sense. And so I stopped him and asked him a question about it. And he said in a very conscending way that my question wasn't very well posed. And, you know, I didn't want to say what I was thinking, but what I was thinking was that I really don't care if it's not a well posed question. I just wanted you to know that what you're saying wasn't clear to me. And I wanted to stop you before you went on to the next thing. And so I tried to put my question a different way. And he still didn't like the way I was putting the question. And he didn't try to find out what it was that was bothering me about the idea. He just kept putting me down. (Circle female, 4801-4802).

On the surface, the reader might conclude that there are inconsistencies between Table 9 and Table 10. The former shows that twice as many males as females felt there was resistance to females, while the latter table shows that about a third more females than males think that females are not taken as seriously as males. We propose that the difference rests in the phenomena. Resistance is a more direct, overt form of conduct, indicating action of an opposing nature. Not being taken seriously, however, implies an indirect, more covert form of conduct, indicating a lack of attention being given to a person. On this score, females are more likely to feel that lack of attention even though they say there is no active resistance.

Table 10

Undergraduate Responses to: "Are Females in Math Taken as Seriously as Males?"

	Males (N = 42)	Females (N = 46)
Yes	57	33
No	43	67
	100	100

> That is a tough question. I don't think so. I think it relates to that other question. It's the same thing. Girls are more accepted as being capable of doint that stuff. They are respected as much as the guys (Northwestern male, 3220).

> If they're as competent as the males in math, then you're asking if there's still the possibility that they would not be taken seriously? Well, I think they'd be pretty impressive if they can handle the material as well as the men could, but they are expected, I think, not to know it as well as males (Chicago female, 335).

What does seem paradoxical, in light of these findings, are the data presented in Table D-12 and Table 11. Students almost universally feel it is important for professors to take a special interest in them -- interest expressed beyond classroom responsibilities. The only difference in Table D-12 is that about a fourth of the males qualify their affirmative responses by saying that special interest depends on the situation, such as a student requesting it. Table 11, however, shows that over twice as many males state that in their estimation special attention never has been shown to them. Almost two-thirds of the females, on the other hand, said that they have received special attention outside of class.

> Yeah, I really do. I think if you know someone's behind you,

Table 11

Extent and Conditions Under Which Special Interest From Professors is Shown to Students

	Males (N = 38)	Females (N = 39)
Never Shown	42	18
In Class	11	13
Out of Class	39	63
Only When Student Initiates	8	6
	100	100

you're more willing to work at something. If you know the professor's really interested. But if he doesn't care, maybe you won't either. (To what degree have any of your professors taken a special interest in you?) Mainly just helping outside of class. And like I said, Roxie called me on the telephone. And she helped me with my paper, gave me some ideas when she was talking to me (Northwestern female, 160).

Yes. If you want to make recommendations for the fall, you have to know the student. And the only way you can know the student is you can start taking an interest in them. (To what degree have any of your professors taken a special interest in you?) One thing at this school, if you want help, if you're having difficulty, you have to go find a person to help you. They do not come out and search for you. Therefore, you have to be the one to initiate the encounter. Once you initiate the contact with a professor usually they're interested and will help you in whatever you're doing. And they'll inquire into how you're doing and what's going on with you. (Has there been any particular professor who has done that for you? Taken a special interest in you here?) One has, yes. And the other ones have been friendly. Enough to say hello, how are you. They remember your name if you see them outside of class or another quarter later. I've had two math profesosrs that remember me outside of class, you know, a couple of quarters later.

> And two computer professors. The only one that's ever said, when I walked into his class I was getting mono and I was really looking terrible, there's only one who's ever said well you look like you're dying (Northwestern female, 1240-1241).

Without comparative data on students majoring in other areas, it is impossible to determine whether these findings are particular to the experiences of students in mathematics or are more generic in nature. Moreover, whether the sex-differences that we had been able to demonstrate constitute educational inequity is problematic. This is not to say that patterned differences do not exist. But, coupled with those dats shown in the previous section of this chapter, we cannot automatically conclude that there are inequities in the sense of unfair inequities.

Undergraduate female math majors typically do not begin their college careers in math with the same focused determination as males. And having run the gauntlet of their high school years, they are well aware of the currently inherent social dilemmas in being a female interested and involved in an academic pursuit typically engaged in by males. Thus, they are sensitized to the potential for differential treatment. Added to this awareness is the everyday experience of being one of the few females in the class -- sometimes the only one. The males do not sound like oppressive types; they sound more like they are beningly insensitive to the everyday experiences of females. Certainly they recognize the overrepresentation of males in math and express concern for females in the area. But, their insensitivity is given away in Table 10 in which over half say that females are taken as seriously as males. This brings the issue of educational inequity into sharp focus. If there is no overt resistance and if females have more special attention shown to them by faculty than to males, then to what extent is not being taken seriously as issue of educational inequity from the standpoint of the institution? And to what extent is it being harder for females to succeed in math a function of the universities *per se* as over against the differentials existing prior to college and which favor males? We ask those questions not to imply answers but to suggest the complexity of the problem.

Significant Others and Role Modeling

Central to the purposes of this study is the designation and assessment of the function of significant others, including role models, in the lives of students in mathematics. Conceptually, we regard this section as a discussion of the identification process, in the sense of one identifying *with* another (See Stone, 1962). We also depart from those theories of role modeling that stress cognitive processes (eg., Bandura and Kupers, 1964) and instead adopt a view that stresses the meanings of social worlds in which individuals live. Briefly, these are the ideas that inform the data to be presented.

Logically, Table D-15 is the place to begin this discussion, since it shows the distribution of persons who the undergraduate respondents say had influenced them in the past. One-fourth of the males and females point to high school teachers and about equal proportions indicate family members (14% vs 17%). Beyond those categories, however, sex-differences begin to appear. Males are seven times as likely to designate male friends (28% vs 4%) while females are only three times as likely to say female friends (6% vs 2%). Also, males are nearly five times as likely as females to name same-sex friends (28% vs 6%). The other major difference is that it is only the females who mention boyfriends/girlfriends category (15%) and only males mention professors (10%). For students who end up as college math professors, these data suggest greater same-sex identification for males, as well the greater lack of influence and identification with non-family intimates. As importantly, they suggest that high school teachers and family members were not part of the sex-differentiation process as seen through the eyes of the students themselves.

We used an inductive approach in obtaining data on role modeling. By that we mean that we had a series of questions that started with the respondents specifying qualities they admired in people (honesty, openness, promptness, etc.),then asking what qualities they admire in professors, then asking if there are people they know who have those qaulities, then if that person is a role model for them. (See questions 28 through 31 in Appendix A).

Table 12 shows that persons designated as those who have the qualities admired. It is instructive to note that females name twice as many people as males, and that males are about twice as likely to say that no one has those qualities they admire. (Likewise, Table D-14 shows that twice as many males say they have no role models). A high percentage name professors (28% vs 39%) and a low percentage, in contrast to Table D-15, name high school teachers. Influence and admiration apparently do not always go hand-in-hand. Males mention their fathers twice as often as females mention their mothers. When

Table 12

Undergraduate Distribution of Persons Designated as One With Qualities Most Admired

	Males (N = 39)	Females (N = 76)
No One	15	8
High School Teacher	3	3
Professor	28	39
Father	15	4
Mother	0	7
Other Family Member	3	7
Male Friend	23	9
Female Friend	10	17
Boyfriend/ Girlfriend	0	3
Other	3	3
	100	100

it comes to friends, however, the pattern is to designate same-sex friends. About half of those people so designated are regarded as role models (Table D-14), which indicates that modeling does not always occur on the basis of individuals we admire, and which also confirms Bucher and Stelling's (1977) findings. The actual designation of role models is provided in Table 13. Note first that females name twice as many people as do males and about twice as many categories. Females, therefore, appear to have greater variation in type of role model. Males are twice as likely to have professors as role models (28% vs 13%) and more than twice as likely to mention the same-sex parent (28% vs 11%). Only females (13%) mention family members other than parents. The major implication of these data is that males model themselves after individuals, primarily a professor or their father, while females model themselves after individual's characteristics. This implication must stand as a modification of Bucher and Stelling's (1977) findings of the prevalence of the "partial role model" type inso far as that type is sex-differentiated.

This issue brings us to the final and perhaps most crucial point of this section. To what extent can female faculty be role models for female students? Table D-13 shows that nearly two-thirds of our sample had taken at least one class with a female professor. This establishes the structural possibility for role modeling. Table 14, however, provides very important data regarding role modeling for females in mathematics. Recall that the critical issue is one of females being able to integrate various aspects of their lives into a workable lifestyle. With this notion in mind, note that a sizable portion of males and females (42% vs 34%) have no knowledge of their

Table 13

Undergraduate Students' Role Models

	Males (N = 25)	Females (N = 56)
Professor	28	13
High School Teacher	12	14
Father	28	8
Mother	0	11
Other Family	0	13
Female Friend	4	4
Male Friend	4	5
Other Friends	24	13
Boyfriend/ Girlfriend	0	7
Other Adult Female	0	8
Other Adult Male	0	4
	100	100

Table 14

Extent of Undergraduates' Admiration of Same-Sex Professors' Lifestyles

	Males (N = 38)	Females (N = 29)
Do Not Admire Their Lifestyles	26	41
Have No Knowledge of Their Lifestyles	42	34
Mathematics Professor	26	10
Academic Lifestyles in General	6	0
Same-Sex Professors as Negative Role Models	0	7
Other	0	8
	100	100

Table 15

Distribution of Persons Who Have Influenced Undergraduates' Career Plans

	Males (N = 54)	Females (N = 60)
No One	9	10
Myself	31	13
Friends	4	3
Mother	11	12
Father	17	17
Other Family Members	3	10
Boyfriend/ Girlfriend	6	8
Mathematics Professor	9	7
High School Teacher	4	8
Spouse	2	3
Other	4	7
	100	100

professors' lifestyles, thus completely eliminating the possibility for this critical form of role modeling. For the rest, nearly twice as many females as males say they do not admire their professors' lifestyles (48% vs 26%(, thus providing negative influence. What is left is three times as many males admiring some-sex professors' lifestyles, thus creating a positive influence. In general, then, these data suggest that for undergraduates, the role modeling process is not a positive force in creating situations that encourage students to pursue mathematics. This is especially true for females, since only 10% say they admire the lifestyles of their female professors.

Career and Family Plans and Expectations

Our final substantive section on this chapter pertains to how undergraduate math majors envision their futures. Table D-16 shows that while a very small percentage do not plan on eventually going to graduate school, about three times as many females as males are unsure about going (34% vs 13%). Males are twice as likely to plan on continuing their educations in math or computer science, and as Table D-17 shows, they are twice as intent on becoming a math professor (28% vs 15%). The exact career plans, both immediate and projected ten years from graduation date, are given in Table 16. But first, we should look at Table 15, which shows the distribution of persons who have been an influence on those plans. Males are about twice as prone to say themselves or no one (40% vs 23%). The distributions for the rest of the categories are about even, with about a third indicating family members. Table 16 shows the actual responses to questions 42, 47, and 48 of the undergraduate interview schedule (Appendix A), and includes only those cases in which all three pieces of information were present.

Table 16

Anticipated Career Routes in Relation to Home/Work Compromises for Male and Female Undergraduates

MALES

Activity Immediately After BA Degree	Nature of Family Life	Activity Anticipated in Ten Years
Graduate school in math	No marriage or children	Math Professor
Job in computer firm	Share responsibilities	Computer modeling
Graduate school in math	Share responsibilities	University Professor
Industry or teaching	Family primary interest	Combine farming/teaching
Graduate school in math	No thoughts	Math Professor
Graduate school in statistics	Sharing; would bring children to work	Statistics Professor
Unsure; perhaps engineering	Would consider staying home	Unsure
Law school	Never thought about it	Practicing law
Doing math	Never thought about it	Doing math
Work; perhaps graduate school	Unsure of demands; compromise on anything	working; perhaps married
Graduate school	Wants someone to raise family	Teaching and research
Unsure	Too abstract to think of	Unsure

Table 16

(continued)

MALES (Continued)

Not going into business	Wants flexibility so can be with family	Unsure
Graduate school in statistics	Flexible, but his job comes first	Statistician
To be a great mathematician	Must accept a working wife; She must raise children	Great mathematician
Graduate school in Physics	Traditional division of labor	Physics Professor
Graduate school	Wife with career; both have primary contact with children	Teaching
Job; then business school	Traditional division of labor	Unsure
Graduate school	Sharing; joint responsibility	University teaching
Graduate school	Sharing, but home is mostly wife's responsibility	Math Professor
Job in math	Active parent; would consider quiting work for few years	Own company
Econometrics	No thoughts	Upper level management

Table 16

(continued)

MALES (continued)

Medical school	Sees problems but no solutions	Working long, hard hours
Graduate school	Minimal compromises; mostly traditional division of labor	Operations research
Ph.D. in math; then medical school	Never thought about it	Combining math and medicine
Job; then MBA	Traditional division of labor	High paying job
Business firm; graduate school	Family high priority	Family and good job
Graduate school in math	Never thought about it	Math Professor
Teaching	May not marry	Unsure
Graduate or Medical school	Unsure; minimal compromises	Either professor or physician
Unconcerned	No problems (now married)	Semi-retired
Accounting	Never thought about it	Own accounting firm
Computer programmer; systems analyst	Wife make major compromises	Better position in computer industry
Marketing research	No compromises	Management in marketing research

Table 16

(continued)

MALES (continued)

Computer science research	No compromises	Administrative position in middle management
Engineer; MBA	Traditional division of labor	Administrator for corporation
Own business	Traditional roles with some sharing	Live in country; have higher degree.

FEMALES

Graduate school in computer science	Part-time for awhile	Architect
Graduate school in math	Take off work for children	Math Professor
Work and raise family	Take off work for children	Work and raise family
Systems analyst	No husband (divorced) Children help out	Systems analyst
A job	Take off work for children	Unsure
Subprogrammer	Daycare	Jr. College teaching

Table 16

(continued)

FEMALES (continued)

Work and raise family	Unsure; will worry later	Family
Unsure	Either full time family or full time work	Full time family or full time work
Computer work or music engineer	Take off work for children	Music
Graduate school in math	May choose not to have children	Math Professor
Accounting	Take off work for children	Wife and mother
A job	Children are priority	Unsure
A job	Take off work for one year; then daycare; husband help out	Get degree in engineering
Hospital administrator	Part-time work	Family
Work and graduate school	Take ten years off for children	Family
Work	Never give up work for children	Work
Computer programmer	Take off work for children	Married and management position
MBA	Give up work for children	Family and work in a firm

Table 16

(continued)

FEMALES (continued)

Graduate school in math	Flexible hours	Math Professor
MBA	Take off work for children	Corporate executive; millionaire
Insurance actuary	Take off work for children	In business
Graduate school in business	No solutions	business/unsure
Programmer	Will not marry	Department head
Medical school	Stay home one year; babysitter	Physician
High school math teacher	Both work full time; help during days	Work nights; masters degree during days
Management	Take off work for children	Graduate school in business
A job	Take time off for children	Graduate school in business
Medical school	Babysitter; nursury school	Physician
Physics	Take off work for children	Wife and mother
Graduate school in math	Never have a family	University professor
High school teacher	Stay home until children are in college	Graduate school in Education

Table 16

(continued)

FEMALES (continued)

Teach math in foreign country	Quit work; maybe work at home	Teaching, industry, or go back to school
Computer work	Take off work for children	Family and work on masters degree
Art school	Doesn't think about it; would give up math, but not art	Working part time in math to support art
Graduate school	Unsure	University professor
Graduate school	Reduce work load	Teaching and family

We present them in this way to show a pervasive sex-differentiated pattern in students' projected futures. The pattern is rather clear cut. The sex-differences in the post-BA expectations are not large; most see themselves earning a living in an occupation in which they use math skills or as going to graduate or professional school. What they see themselves doing in their early thirties, ten years after they graduate, however, is highly sex-differentiated. The males envision career achievement; the females envision career compromised by family obligation. For females, the middle column of Table 16 might be seen as the process through which their careers are modified. For the males the family is an expected and desirable experience, but it is incidental to their careers. They do not see family and work as a single unit.

The data in Table 17 show the quantitative distributions of students' responses to the questions on home/work compromises and coordination. As we see, 22% of the males never have even thought about the issue, 10% envision no problems, 21% expect the traditional division of labor; a total of 59%, versus 0% for the females. On the other hand, 47% of the females expect to quit work in order to rear their children. Table D-18 shows the distributions of what the students expect to be doing ten years after the BA degree. A vast majority of males (84%) expect to be working full time, compared to 45% of the females. The quotes from the interviews show certain variation on these themes, and shed additional light on this matter.

> I think I would need a wife -- someone to come home to. Once you get out of college, if you're living by yourself,

Table 17

Undergraduates' Anticipated Solutions to Problems of Coordinating Home/Work Activities

	Males (N = 40)	Females (N = 48)
Unsure	5	10
Never Getting Married	5	4
Will Not Have Children	0	4
Currently Married, Spouse Helps	0	4
Divorced With Children	0	2
Daycare	0	4
Envisions No Problems	10	0
Problems, but Undefined	5	0
Have Not Thought About it	22	0
Part Time Work	0	4
Traditional Division of Labor	27	0
Quit Work for a Few Years	8	47
Contingency Basis or Sharing	18	21
	100	100

it's hard to meet people and keep close friends. And I think it's a good way to have someone there. You know, to have kids (Northwestern male, 2189).

Between home and work? The compromise is going to be you are not going to be able to expect....you know my mother always has dinner on the table when you walk in. You are not going to be able to expect that because both of you are going to be working people. I am not going to be able to expect the same things that, say, my father expects from my mother. Her being a housewife. I am going to have to compromise in doing the dishes and cleaning up and in going shopping and all those types of things. It is going to have to be an equal partnership in just about everything. There will be conflicts between both of our schedules and things like that. The basic compromise is that I won't be able to demand from her what you can demand from a housewife because she will have commitments too (Northwestern male, 2755-2756).

That's really tough. So many girls....I would like to marry a typical housewife. I know that is really sexist. I am afraid that it is going to add up that she is going to have to have a job and I am too. If we were to have kids I don't know if she's going to quit her job or what. I don't even want to think about that (Northwestern male, 3238-3239).

> (To what extent is marriage part of your future?) I can't, well I would say like you know it's possible. I can't decide if I would wait until....I mean, I certainly wouldn't get married as an undergraduate student and I don't know for sure if I would. Even if I got married in graduate school, it would be like towards the end. But like as far as special concessions I would make for anything like that I don't think there are any. Like as far as choosing a career or something that would be sort of amenable with the married life. I don't think I would have to make any special concessions. Like I think any career in math is probably not different from any other career. (Do you think you'll have children?) Oh I think so. (What about the task of coordinating home and work obligations and conflicts?) I really can't see that there would be any career conflicts for a math career. I mean most of the professors here are married and have families and they don't seem to have any big conflicts and I don't think it's any different from any other job (Chicago male, 2643).

Females give quite different answers.

> I think that I'll be missing out on a lot if I just get into math and ignore the other part of life and then during school I get involved and sort of forget about it for awhile. It's also one thing I talk a lot about with people. Will I be willing to compromise, like say I get a job at a really good school and my husband had to go somewhere else and I

sort of understand that I'd have to secondary my career because for awhile I'll be out of it raising kids and he'll have to get enough money to support us. (What kind of compromises would you be willing to make?) I don't know. Part of it depends on how decent I am in research. At times I'll think I'll go anywhere I can, just in a high school, and that is when I like a specific person and I can envision feeling very happy just being a mother. There are times, especially after I've had a relationship that has fallen through, I sort of say that I wouldn't be willing to give up very much at all. I'm going to find a man that is willing to go where I need to go. I don't know, it doesn't even average out. I guess right now I can envision teaching at a college, kind of a low keyed one, and at least while my children are young, devoting most of my energy toward the home. I would really like it if my husband could help out with that. It's not only for the reason of needing to do math, but so I don't feel I'm hauling it alone and he doesn't care about it. I would really like a partnership like that. I don't fall in love with too many people. I'm willing to accept pretty much whatever comes along (Chicago female, 4054-4055).

That's a problem because, say, if I go head strong into a career what if I decide I'm going to have kids. That's the problem if you have kids and you also have a strong career. What do you do? If I have kids I want the kid to be -- I don't want to say like me -- but I want to raise the children myself. I want the child to have my values and I want to have a part in it. If that kid turns out at seventeen to be a drug addict, I want it to be my fault. I don't want to say well I shouldn't have dropped that kid off at the day care center. I can't imagine taking your little 2 or 3 year old and putting them with a bunch of little kids and just having one person. It's like the kid is in school, but the kid can't get the attention that it's going to get if you're home with it all the time and you're taking care of it. As much as I hate to say it, I would be going out of my mind. But then again maybe I wouldn't. Maybe I would enjoy it because it would be my own child. It wouldn't be like I was babysitting or something. (How are you going to combine a career and a family? Are you going to give up your career?) I think I would. At least I don't find there's a problem once the kid reaches school age. Then I don't think there is any problem because my mom was home with us the time when we were little and when we were in school she worked. She was an accountant at a hotel. It was almost right across the street so it was real convenient hours. She worked full time, but she didn't work full time, you know what I mean. I worked out really well. She didn't make that much money but she kept busy. And I got the impression that the mother should work. Yet, when I was little my mom was always there and that's the way I think marriage should be. I don't

> think that you should ship your kids off unless you work nights or weekends or something (Northwestern female, 3811-3812).

> Well, I plan on getting married. I estimate like twenty-four or twenty-five, something like that. And I plan on working when I'm married. And my husband will definitely be aware of that, you know, that this is what I want to do. I want to work. I don't want to sit home and be a housewife and all. That to me is boring. I don't know. So, I plan on having children. I don't know when to fit children into my schedule. It (chuckle) might be dull. Sure, I could take off a couple of years from work to have children. But I would want to go back to work. But, then, I would also want to stay home with them while they're growing up because I feel that it's important that they're not sent off to some day school or something like that. And I feel it's important that the mother is there to take care of the children. (Why is that important?) I don't know, my mother did it. And I just think it's better for the children. They're more well-rounded. They might not be as messed up or something. That if there's someone there all the time that cares for them, than if they were sent away like they went to day school or something like that. It's like they're neglected (Northwestern female, 4640-4641).

In one sense, these patterns of responses are not unusual. They look very much like the traditional arrangements. In another sense, however, we get glimpses of change. The increased careerist orientation of this cohort of women is reflected in their first job aspirations, and we might speculate that if they were to continue these career without interruption, their career placement might well approximate that of males. The middle column of Table 16 and the tabulations in Table 17 can be interpreted as representing these women caught in the intersection of two generations in which they are being pulled in two directions. Their current cohort identification pulls them into the job market and full time careers, and their identification with their parents' cohort, in which they learned to define their futures in terms of family roles, pulls them into motherhood and wifehood. They do not necessarily place one set of priorities over another. We beleive that the problem is that this particular cohort in this particular historical era has not acquired a working set of routines through which the mix of two careers and family life can be worked out to mutual benefit and equity.

Summary for Chapter IV

This chapter has presented data from interviews with undergraduate majors in mathematics that help us understand those processes that contribute to sex-differentiation in mathematics education. We showed that there are few differences in schooling during high school (eg., participation in advanced math tracks), but that where as equal proportions of males and females were encouraged to continue in math during college, a higher proportion of females were discouraged. It is clear, therefore, that some females were receiving mixed messages regarding the appropriateness of mathematics as a long term pursuit.

No such mixed messages were detected for males.

As high school students, the vast majority of undergraduates aspired to professional occupations. No major sex differences were found, except that only males specified that they wanted to be professors of mathematics. Patterns of parental influence generally reflected these career plans, and thus we must conclude that parents were for the most part supportive.

There is a fairly clear sex-differentiated pattern in the reasons students give for why they majored in math in college. Although, as expected the overall pattern was one expressing an interest in math, males attributed their choice of major to their positive evaluations of the subject matter of math itself whereas females described their choice in terms of sets of circumstances which were unrelated to math as subject matter. Correspondingly, the problems for males are expressed in terms of dealing with subject matter (eg., solving problems, learning theorems, dealing with abstractions) while the problems for females are expressed in terms of social relationships (eg., dealing with stereotypes). The consistency in sex-differentiation, therefore, is one in which males choose math as a college major because they enjoy dealing with the subject matter and they define the major difficulties to be overcome in terms of that subject matter, and females select a major in math as a consequence of some set of factors other than math itself and define their major difficulties in terms of social relationships.

The barriers experienced by undergraduate females in college are covert in nature. Both males and females think it is harder for females to succeed in math, but they also feel there is no overt resistance to females. What does emerge as a highly sex-differentiated pattern is that females feel that they are not taken as seriously as males, even though they are more likely than males to state that they receive special attention outside of class. This is an apparent contradictory pattern, but we cannot dismiss it on the basis of internal inconsistency. What we believe is important is that females have the subjective experience of not being taken as seriously as males, because that kind of experience can be very discouraging for students. We cannot empirically specify the source of that subjective experience, but we cannot at the same time deny the reality of it. That reality, we contend, is the primary "barrier" (that term seems to us to be too strong, so we use it cautiously) that enters the experience of female math majors.

The pattern of role modeling was a surprise to us. We expected to find potentially negative experiences of females students, such as not being taken seriously, neutralized by positive experiences with female faculty. Rather, we found something very close to the opposite. Female students are more likely than males to have negative images of same-sex professors. In fact, we estimate that positive role modeling processes are possible in only 10% of the cases. This estimation assumes that effective role modeling can take place only when the person doing the modeling has a positive image of the person or characteristics which serve as the model. Therefore, since only 10% of the undergraduate females specify math professors as role models, we assign the 10% probability of the process occurring.

The remaining portion of this chapter dealt with anticipated patterns of participation in career and family. Females tend to anticipate very contingent futures, in which family activities are seen as modifying career activities. Most females express a great deal of ambivalence and frustration about this contingent situation. Males, on the other hand, tend to anticipate very linear futures, in which family activities are independent of their career activities. We believe that the sharp sex-based divisions in these data are part of a larger pattern of sex-differentiation that emerges prior to college. It is not only anticipated futures that are contingent for females, but their career plans when in high school, the mixed messages they received in high school, the reasons for choosing a college to attend, the basis for selecting a major in mathematics, and their experiences of not being taken seriously in mathematics. Unlike males, they have lived for a number of years in a world of contingencies, where norms of conduct have become less clear and where their self-projections have become reflections of those contingencies. In this sense, the overall context of experience even for females who are talented and productive in mathematics militates against a focused pattern of participation.

CHAPTER V

ANALYSIS OF THE DATA - II:
GRADUATE STUDENTS

This chapter presents our findings from interviews with graduate students in mathematics. As in the previous chapter, the data are organized longitudinally, and include sections on entry into graduate school, significant others and role modeling, and career entry.

Sample Characteristics

Graduate students come from families in which the father was employed in a professional or business occupation (roughly 70% of the sample). Also, over half of the mothers of these students worked fulltime, although a very low percentage (5%) were in professional occupations. Likewise, their parents were fairly well educated. Sixty-four percent of males' fathers and 44% of their mothers had at least a college education, while 57% of females' fathers and 36% of their mothers were so educated. Thus, there is a slight sex difference in parent's educational background, with males' parents being more educated than females' parents. It is only the males, for example, who have fathers with professional degrees (16%). The average age of Northwestern University and the University of Chicago male and female students was 26; for the University of Illinois at Chicago Circle females it was 31, and for the males it was 28.

Entering Graduate School and Dealing With Others

Data pertaining to main interests in high school, degree of encouragement to continue mathematics, career plans while in high school, parental influences and support of career plans, reasons for choosing a particualr college, and reasons for majoring in math are provided in Tables 1 - 16 in Chapter IV. Those data strongly suggest that by the time students are ready to enter graduate school, males have a more focused orientation than females toward mathematics. This contention is supported by Table 18, which shows that twice as many males (79% vs 38%) had selected mathematics as a career choice while they were undergraduates, and eleven times as many females (44% vs 4%) had selected high school teaching. Table 20 adds support to the contention that males are more specifically oriented toward mathematics upon entry into graduate school by showing that nearly 75% considered nothing else besides mathematics -- a rate nearly 50% higher than that of females. Table 19 shows the distributions of reasons why they decided to go to graduate school in mathematics. While about the same proportions of males and females indicate long term and occupational objectives as their reasons, it is only the males (32%) who say that their choice was an expression of intrinsic interest in mathematics. The following quotes from the interviews illustrate this reason.

> I like pure math. And, having decided to pursue it, that's the only option there was (Chicago male, 1652).

> Well, I think because I liked math. I don't think my primary motive was to finish so that I could get a job in it. It was really because I liked it. And, I wanted to continue studying it. And, the truth is if you don't like it, you're in bad shape if you want to get a job doing it, you know,

Table 18

Distribution of Graduates' Career Plans While in College

	Males (N = 23)	Females (N = 16)
Unsure	4	6
Mathematics	79	38
High School Teacher	4	44
Job After Bachelors Degree	4	0
Computers	9	6
Research	0	6
	100	100

Table 19

Distribution of Graduates' Considerations for Graduate Degree Choice

	Males (N = 22)	Females (N = 22)
Expression of Intrinsic Interest	32	0
Long Term Objective	18	14
Occupational Objective	45	41
Avoidance of Less Desirable Area	5	14
Circumstance	0	27
Good at Math	0	4
	100	100

Table 20

Distribution of Graduates' Consideration Other Than Graduate Math Degree

	Males (N = 22)	Females (N = 15)
Nothing	73	53
Something Else	27	47
	100	100

> because what I'm doing now is pretty much what I'm going to be doing. So, that's probably a good reason (Northwestern male, 1914).

On the other hand, it is only the females (27%) who say that they choose to go to graduate school in mathematics because of some circumstance. These "circumstances" usually took the form of stories told to the interviewers.

> I thought that math was probably a more reasonable thing than french in terms of my perceptions of both the job market and the caliber of students I would have. Also, I felt that Carol was right. I did need to know a lot more math as a matter of fulfillment for myself whereas I didn't have that same pressing need with any other subject. And also, my senior year I spent the year out at Argon on their research program, so I was surrounded by people in the sciences who were planning on going on in the sciences which made it a more natural decision to drift into (Chicago female, 3998).

> Well, there's the personal side to this. I was engaged for a long time to my husband -- now my husband. And, I had promised him when I finished my masters degree I would stop because we couldn't get married because I always was traveling around and looking for a new course and taking a new course here and there. So, I promised him I would stop. Anyway,

> one day I was working and he said, "Look, I want to talk to you. I want to talk to you. I want to ask you if you want to take your PhD." I felt he was kidding around or something, because he was all set to take a job in Brazil because you can get a good salary there. But he said, "No, I'm serious. I want to go abroad, but I think it's easier for you to get your courses here. And then we could go together. I could get something else." So I said that I have many cities that I can study in. No problem, and I wouldn't have problems getting grants, and I could get a very good letter of recommendation to get a nice grant. And then we started to research for a place to go. And that's the whole story (Chicago female, 5892-5893).

Table E-24 shows that a majority of graduate students think that there are no sex differences in math ability, although females are somewhat more likely to think so. When asked about perceived differences between male and female graduate students, however, females are four times as likely to say that females are not as devoted to math as are males (22% vs 4%) and are three times as likely to say they do not perform as well (9% vs 3%). These differences may well be related to the patterns shown in Table 21, which shows males' definitions of problems for males and females' definitions of problems for females in mathematics. Categorizing "math itself," "job market," "not enough time," and "career tasks" together, all which relate to work activities, we find that 41% of the males and only 4% of the females regard this as a problem for their sex. Categorizing "isolated in department" and

Table 21

Graduate Students' Same-Sex Perceptions of Problems in Math

	Males (N = 28)	Females (N = 24)
No Barriers	18	8
Math Itself	18	0
Isolated in Department	20	0
Motivation/ Discipline	11	13
Respect from Colleagues	4	17
Job Market	7	4
Family Responsibilities	0	21
Quality of Life Suffers From Overwork	7	4
Not Enough Time	4	0
Career Tasks*	11	0
Sexism	0	21
Inadequate Background	0	8
No Networking	0	4
	100	100

* publishing, tenure

"motivation/discipline" together, which relate to the personal aspects of work, we find that 31% of the males and 13% of the females name this problem. Finally, categorizing "respect from collegues," "family responsibilities," and "sexism" together, which pertain to interpersonal and social relationships, we find that 4% of the males and 59% of the females naming that problem. In sum, male problems tend to be heavily defined in terms of work and career; female problems tend to be defined in terms of the social arena. Note the remarks made by males graduate students.

> It would be just the subject itself. The work that you have to put into it in learning the material. I think that is the same for males and females. I guess the idea of math is sort of a language itself. It has its own terminology and symbolism. It is like learning a language really. I think that if a person, male or female, gets over the idea that it is nothing exotic, but that it is based on logic, they could learn the material. But a lot of people have a barrier with the symbols and whole language of mathematics. Once you can see through that, it is something that can be overcome. I don't see it as a male problem as opposed to a female problem or anything like that (Northwestern male, 3548-3549).

> Probably, in a sense of you're feeling overwhelmed by the immensity of the subject. Certainly, at this point, I feel as if I just should think of one of these tiny slivers from this huge monument. I'll try to break something down and I

> really have to kind of restrain my impatience. That feeling that I'm not really doing anything productive with it because I really have to learn quite a bit more before I will have the necessary tools in hand to be able to do anything worthwhile (Northwestern male, 1984).

> Just the fact that this research is too difficult, and time consuming. I think it makes the rest of your life very difficult. I mean, I know in my case it's tough to say to my wife, "No, I can't go to a movie. Or, I don't want to go to a movie. I should see if I can get something done this evening." Or I come home after a hard day all grumpy and end up having a fight. It's a strain on just your whole being. Just doing this (Northwestern male, 4439).

Females, however, differ in their assessments of problems.

> You have to put aside other facets of your life. I mean to do this thesis I am having to put aside some things that I would really not rather put aside. Outside interests that make me a fuller person. I think this bothers me as a woman more than it would bother some men. There are choices now that I am being forced to make because I am a woman. We are trying to think about when we want to have children and putting those kinds of plans around my degree. We just got married. So as a mathematician I have one or the other

goal. I don't see any way I can do both satisfactorily. My advisor thinks if I get pregnant I'll be a waste of time because I am going to stop to raise a baby (Chicago female, 3628).

The hardest thing to do is trying to take care of children and having a math career. It's just something that takes a lot of time and it's something that really can't be interrupted when you're sitting around working on math and somebody comes up and interrupts you, it totally ruins what you're thinking about and little kids have a tremendous interruption value. And so I think that would probalby be the most difficult thing and it seems to be something which is the woman's problem even if you have a married couple. Particularly because a lot of times when you're getting started, they (married couples) will be working in two totally different places. One of the female Dickson Instructors here, for example, her husband is at Wisconsin at Madison and they decided since she was getting more money than he was and would have a big apartment here with the kids that he could have a little teeny apartment at Madison and come and visit on the weekends. And it's going along pretty well, but when the babysitter quits, her life goes all to pieces because she has teaching to do and she has her research to do, and then she gets these two kids dumped on her, and I think that's probably the hardest thing. I shouldn't be, because there are two people. There should be some way of

> working it out, but it's very difficult when they're two people far apart. Somebody is going to get stuck with the two little kids, and you can't really say, "Well, don't have kids, because that's ridiculous (Chicago female, 6122-6123).

Table 22 shows, in a word, that males study more than females. While 72% of the males study math six or more hours per day, only 28% of the females do so. One way to think of these data is as responses or solutions to the problems identified in Table 21. Males see work as a problem and they tend to spend maor time working; females do not see work as their major problem and they spend less time working.

Graduate students study mathematics not with others, but alone. It is a singular kind of learning experience (Table E-14). However, it is not a totally isolated experience, and so we are interested in with whom males and females discuss mathematics. Table 23 shows the distributions of the frequency of contact among graduate students, and it tells us that males tend to have more frequent contact. The sex-differences can partially be explained in terms of environment, as noted at the bottom of the table. Specifically, the females who have the least amount of contact tend to be married students at UICC, and the males who have the most frequent contact are from Northwestern and share a common office for graduate students. When it comes to actually discussing math with someone on a fairly regular basis, we find in Table 24 that males tend more than females to talk to other male graduate studnets (64% vs 37%), while females utilize faculty more so than do males (21% vs 8%). Even though females show an edge in having regularized

Table 22

Distribution of Graduates' Hours per Day Studying Math

	Males (N = 22)	Females (N = 14)
3 or Less	14	29
4 - 5	14	43
6 - 7	32	21
8 - 9	26	7
10 or more	14	0
	100	100

Table 23

Distribution of Graduates' Extent of Contact With Other Graduates Concerning Math

	Males (N = 25)	Females (N = 17)
Everyday, Continually	32*	24
Everyday, Limited	40**	17
Less Than Everyday	28	59***
	100	100

* Due to common office

** Due to specialization

*** Department not centralized; commuter campus

Table 24

Distribution of Persons With Whom Graduate Students Regularly Discussed Math

	Males	Females
	(N = 24)	(N = 19)
No One	20	26
Female Graduate Student	8	5
Male Graduate Student	64	37
Female Faculty	0	5
Male Faculty	8	16
Other	0	11
	100	100

discussions with faculty, males appear to have somewhat more frequent contact with them. Table 25 shows that 56% of the males and 41% of the females say that they deal with faculty at least once a week. Boiling issues of faculty contact down to the students' major advisor, however, we see in Table E-17 that there are no sex-differences whatsoever in students' feelings of being encouraged -- a large majority of each feel they are encouraged.

The pattern that is emerging so far points to males having had an early career interest in math and going to graduate school as an expression of that interest. Once they get there, they see their major problem as almost exclusively work-related, and they tend to put in long hours studying. They have fairly frequent contact with faculty and discuss math on a regualr basis with other male graduate students. Females, on the other hand, were typically more interested in teaching at the high school level and entry into graduate school tended to be the result of certain "circumstances." Once they get there, they see their major problems as primarily social in nature rather than as work-related. They spend less time studying, have somewhat less contact with faculty, but discuss math on a regular basis with faculty more so than do males. The next issue to be addressed, therefore, pertains to the influence process and significant others.

Significant Others and Role Modeling

The procedure for obtaining data on role modeling processes for graduate studnets was the same as that use with the undergraduates, and has been described in the previous chapter. Our conceptual approach also remains identical to that in the previous chapter.

Table 25

Distribution of Graduate Students' Amount of Contact With Math Faculty

	Males (N = 24)	Females (N = 16)
Hardly Ever	28	47
Less Than Once A Week	16	12
Once a Week	36	29
Every Few Days	20	6
Every Day	0	6
	100	100

Table 26 shows that males are more likely than females to name a professor as the one possessing qualities they admire (71% vs 45%), while females are three times as likely to mention friends (23% vs 8%) and twice as likely to mention family members (12% vs 6%). The actual qualities admired in a professor are shown in Table 27. We believe they cluster into two sex-differentiated styles of relating to faculty. For females, 66% of the responses are accounted for by "teaches/communicates well," "knowledgeable," and "organized" (compared to 17% for the males on the same items). These items can be thought of as representing an emphasis on the clear communication of knowledge about mathematics, particularly in a lecture format. Quotes from the female graduate students demonstrate further this emphasis.

> The fact that they know the material well. That they're able to structure activities in which you can learn a lot. Even if it jus is "read chapter six in two weeks and we'll have a test on it." At this stage of the game, you have to master the material, and a lot of what you learn is dependent on what they throw at you. If they don't throw enough at you or help structure you in terms of covering the material....Those that are able to structure even though it keeps you busy....sometimes you think "oh god." But even under all the pressures of the deadlines and stuff, you walk away from the class after you've finished it and say "wow, did he pull it off" (Circle female, 6636).

Table 26

Distribution of Persons with Qualities Graduate Students Admire

	Males (N = 34)	Females (N = 26)
Advisor	24	18
Other Professors	47	27
Graduate Students	12	12
Friends	8	23
Family Members	6	12
Spouse	3	4
Other	0	4
	100	100

Table 27

Distribution of The Qualities
Graduate Students Admire
In a Professor

	Males (N = 42)	Females (N = 29)
Quality of Work	12	0
Involved in Math	12	0
Teaches/ Communicates Well	17	39
Personable	19	7
Concern for Students	31	17
Researches Well	2	3
Integrity	5	7
Confidence	2	0
Knowledgable	0	17
Organized	0	10
	100	100

> Teaching ability, that's the one thing, I really think. If they can get the ideas across and make them clear in the classroom, not just throw some stuff in front of you and hope that you go home and read the book and learn. I think I really admire the teaching (Circle female, 2147).

> If they can explain something clearly. That is probably the most important thing. I think that they should be well versed in their field, of course, but that is not the most important thing. The most important thing is if they can explain it to me (Circle female, 3274).

The responses of males, on the other hand, imply a different style of relating to the faculty. For them, 74% of the respnoses are accounted for by "quality of work," "involved in math," "personable," and "concern for students" (compared to 24% of the females on the same items). This style, we believe, is one in which the emphasis is placed on a joint student-professor involvement in math and in which professors can be approached on a one-on-one basis by students. The following quotes help to amplify this style.

> I think that it's probably changed as I've gone along. At this stage for a faculty member, it's approachability and not being pretentious and being somebody who will talk at your level and is interested in you. But there are some people who still feel compelled to prove themselves at the expense of graduate students. That's very repulsive. (Northwestern male, 1866-1867).

> I guess what kind of work he's done. You know, has written good papers and that kind of thing. But then, also, whether he is someone who can talk to others about what he's done in a very coherent and conceivable manner. And, of course, certainly it's very helpful to me if he has interest in talking to graduate students at any time in that way. I'm not sure how far that goes with my admiration of the professor as a person, but it certainly makes life a lot easier. Also, it's good for graduate students when someone has a real interest in watching students develop and playing a role in that development (Chicago male, 5721).

> To admire him as a professor he has to either be dedicated to his teaching or be dedicated to his research. But there are some special qualities for a mathematics professor. A mathematics professor has, and you admire him, if you see he has the power to do things I would like to have. Or if you see an enormous touch....there is a notion of mathematical culture. With mathematics being so difficult, you get to know very few things. I know, say, analysis, but know very little algebra. And I know, say, very much less topology. And I know some differential geometry, but very little. And when you see somebody who just knows a lot of everything, you can't stop admiring that person (Chicago male, 4248-4249).

We suggest these styles as an aspect of the identification and influence process insofar as they form an imagery from the standpoint of students of exactly whom they are dealing with when they interact with faculty. Related to this is the actual designation of role models shown in Table 28. First, we should note that, as with the undergraduates, males are more prone to say that they do not have role models (22% vs 8%). Beyond that, 56% of the males name faculty as male models, compared to 34% of the females, while females are more likely than males to name family members (25% vs 8%). This difference is also shown in males somewhat more frequent response that faculty have influenced them regarding the best way to do math (Table E-8).

One of the crucial issues raised by this study is that of the effectiveness of male faculty as role models for female students. The results are given in Table 29. Most students think they can. Only the males say they cannot, and about one-third of the females say it depends on the situation. Again, we provide some direct quotes from the interview to add flesh to these percentages.

> Well, certainly not if they're obnoxious sexists. But being good teachers or good mathematicians real honestly doesn't have anything to do with sex. So once you're aware of this, certainly by the time you've become a graduate student, your ability to do research and to do good teaching, I think, are not sexually related. So you can emulate almost anyone who's good at it (Chicago female, 2118).

> Sure. As professionals, not as personal things. Like I said, families are important. I had a good family. If some professors fall into that category then I would probably

Table 28

Distribution of Graduate Students' Role Model

	Males (N = 26)	Females (N = 24)
No One	22	8
Math Professor	35	25
Advisor	31	14
Friend	0	8
Family Member	8	25
Spouse	4	0
High School Teacher	0	8
Boyfriend/ Girlfriend	0	8
Other	0	4
	100	100

Table 29

Graduate Student Responses to Whether Male Faculty can be Effective Role Models for Female Students

	Males (N = 23)	Females (N = 16)
Role Models Not Important	9	0
Yes	74	63
No	13	0
Depends on the Situation	4	37
	100	100

admire them for that, for their family life (Circle female, 3174).

Yes, the same ways that they can be for male students. In graduate school, the things that graduate students look for in a professor are the same, whether the student is a male or a female. Obviously, if a female graduate student sees a female professor in a certain position, they may try to emulate that in a sense of that they think, "here is a woman who has gotten where she has gotten despite prejudice or whatever." Maybe that might be a factor. But I don't see any reason why a male professor can't be a role model either because they may be brilliant in their field and a good teacher, a good reseacher, whatever. There's no reason why a female student can't look upon that as something to follow either (Northwestern male, 3560).

Sure. Why not? If you see somebody who's doing what you'd like to be doing, it doesn't really matter if it's a man or a woman. I mean the only thing that you might notice, and it's something that I've noticed a couple of times, is that most of the male faculty members are married. Therefore -- I probably shouldn't say "therefore" but it happens that their wives cook and clean. They don't have to worry about any of that stuff. So you would sort of like to have a wife, that syndrome, but mathematically speaking I don't see any reason why (Chicago female, 6130-6131).

I think that to some extent they can be. But it would be fine if my advisor was a man and I could look up to him in various ways. But there would be some women around. There is one post-doc who is a woman who has children. But I mean something as simple as what if you are married and have kids and you are on faculty. What do you do? I think most of the men, a lot of them are older and have wives who don't work. I mean, I was really impressed one day when one of the male professors that I had said he would like to do such and such later today, but that he had to leave right after class because one of his kids had to go to the doctor. That's like saying, "My wife works. What do you think?" It's like, "Oh ok, it's fair that you have to leave here." I mean it was sort of mutual. I would not expect that from them. Whereas you expect that a woman would be going to do that. What would it be like to be a female professor and have male graduate students who were listening to you? I have never seen that (Chicago female, 3037).

Well, I guess so, because otherwise the women are in bad shape (chuckle). There's not too many women mathematicians. I don't think of anything in particular, any quality that I get from the faculty which is definitely associated with male or female. And, therefore, I wouldn't expect that they would have any difficulty in transmitting it to the women any more than to the men (Chicago male, 2351).

> Definitely. The one exception that I know of was a girl who was in her fourth year. She transferred here from another school, and she took a male faculty member as her advisor. And she was doing relatively well and she had no complaints about his fulfillment of that role. She was much older. She had been married previously. She did not really need a female role model in mathematics. She was a very mature individual. And so I think she did not feel the need to seek out a female role model (Northwestern male, 2410).

> There's a person on our faculty who is very efficient and knows everything about college policies. You go to him with a question and he can answer it. He is very competent. He is in physics. He is a very competent physicist. I think he's a good teacher, even if he's not, he could be. There could be such a person. He is an excellent teacher. Now, I don't see why that could not be a role model for me (Circle female, 3281).

All in all, we think the data in this section show that males identify more with their male faculty on a more persistent and individual basis. This pattern is not exclusively that of males, but females are more likely to identify with family members and friends, and they adopt a quite different style of relating to faculty than do males. What this section specifically adds is that the worlds of male graduate students are narrower than those of females; they are defined in terms of the work of mathematics and the significant people with whom they identify are the professors who are likewise involved in mathematics.

Leaving Graduate School and Entering Careers

This section is devoted to an analysis of the process through which graduate students attempt to professionalize themselves, prepare for the world of work, and enter lives of career and family. Table 30 shows the extent to which students go to others for advice about career management. In general, females seek advice somewhat more than males (54% vs 40% -- data not shown). About a third of each seek advice from professors and females are about two-thirds as likely as males to use other graduate students (69% vs 47%). Whereas Table 30 pertains to action taken on the part of students, however, Tables 31-34 pertain to the sponsorship of students, or action taken on the part of professors. Table 31 shows several interesting findings. It shows that over a third of the females don't know what the term "sponsorship" means, whereas all the males did, that twice as many males see sponsorship in the highly instrumental sense of a professor getting one a job (36% vs 17%), and that three times as many males see it as a form of special attention (20% vs 6%). The following quotes illustrate the thrust of the differences in how male and female graduate students view sponsorship.

> (How important is it to be sponsored?) Very important. Yeah, I have a lot of areas that I'm interested in and to remain interested in one area I tend to be somewhat influenced by the enthusiam of someone else for that area. They start pointing directions where there are interesting ways to go and then I may decide on one and start following. And then

Table 30

Sources of Advice and Information
Concerning Career Management
Used by Graduate Students

	Males	Females
	(N = 18)	(N = 11)
Professors		
Yes	33	36
No	67	64
	100	100
	(N = 17)	(N = 13)
Graduate Students		
Yes	47	69
No	53	31
	100	100

Table 31

Distribution of Graduates' Views of Sponsorship

	Males (N = 25)	Females (N = 18)
Don't Know the Term	0	39
Doesn't Exist	12	6
Professor Gets You a Job	36	17
Professor Takes Under Wing	20	6
Funding	12	11
Thesis Advising	12	0
Professionalization	8*	21**
	100	100

* networking, publishing, etc.

** networking, generally supportive, helpful to students

> you have someone.... more encouraging along the way (Northwestern female, 2602).

> Your faculty advisor is supposed to help you get a job. He might show good representation because he has contacts.... They take an english word, put on a polished ending, and it turns into a heap of protection. Like the godfather. This is about what you have in mind? Being under someone's protection? I can't see that they mean exactly the same as protection. It's sort of like pull. It's like having somebody's contacts at your disposal (Chicago male, 1717-1718).

Females are more likely to see sponsorship as necessary (Table 32), and there appear to be no major differences in their assessments of whether or not they are in fact sponsored (Table 34). What needs to be pointed out, though, is that when males and females talk about sponsorship, they are for the most part talking about very different things. Females tend to think of it as a nurturing and generally supportive process; males tend to think of it as an instrumental process directly linked to career payoff. This same general pattern for males is implicit in Table 35, which shows the extent to which students attend and participate in professional meetings. Succinctly, females are more likely than males to attend, but males who attend are more likely to participate. Obviously both activities are important for professionalization and launching careers. but participation carries more career payoff than attending a meeting and not participating.

Table E-25 shows the distributions of students' designations of

Table 32

Distribution of Graduates' Perceived Necessity of Sponsprship

	Males (N = 18)	Females (N = 10)
Yes	50	90
No	11	10
Only Desirable	39	0
	100	100

Table 33

Distribution of the Occurrence
of Graduates' Sponsorship

	Males (N = 19)	Females (N = 13)
Yes	47	54
No	42	31
Not Much	11	15
	100	100

Table 34

Distribution of Graduates' Perceived Differences in Male-Female Sponsorship

	Males (N = 20)	Females (N = 12)
No Difference	65	75
Don't Know	25	8
Female Students Feel Uncomfortable With Male Professors	5	0
Females Have Fewer Sponsors	0	8
Female Students Have Female Professors	5	0
Females End Up in Traditionally Female Places	0	8
	100	99

career options with training in math. Males are more likely to name multiple options (51% vs 30%), are more likely to mention academia, and less likely to mention industry or secondary school teaching. In fact, males never mention the latter option. Table 36 shows the career aspirations of graduate students. Over three-fourths of the males compared to two-fifths of the females, aspire to be a mathematics professor. Females' responses tend to be more evenly distributed, with major differences in the fact that 18% want to be secondary school teachers and another 18% are unsure of their career aspirations. Table 37 shows the kinds of problems students encounter once they begin those careers. About a fourth of the females don't expect any problems. Only males mention math itself (35%) and insecurity about their abilities (14%). Also, over twice as many males as females mention the job market as a problem (41% vs 17%). Females mention doing the thesis (11%), personal insecurity (23%), and sexism (11%). Similar to the pattern of responses pertaining to problems in graduate school, males' responses tend to be highly work-related and females' responses tend to be more interpersonally related.

> I really think if I were less shy, that would help a great deal. I think if I'm more diplomatic that would help a great deal. I was teased the other day that I wouldn't get my degree until I learned to be diplomatic (Circle female, 5686-5687).

> It's not really a question of obstacles for me. It's just a question of bench marks, or certain levels that I have to push myself up to. Now, of course, you know, like every

Table 35

Distribution of Graduate Students
Who Attend and Participate
In Professional Meetings

	Attend		Participate	
	Males (N = 25)	Females (N = 15)	Males (N = 11)	Females (N = 10)
Yes	44	67	55	30
No	56	33	45	70
	100	100	100	100

Table 36

Graduate Students' Career Aspirations

	Males (N = 25)	Females (N = 17)
Math Professor	76	41
Industry	16	18
Secondary School Teacher	0	18
Computer Science	4	5
Unsure	4	18
	100	100

Note: Circle males constitute 75% of those who want to go into industry; Circle females constitute 100% of those who want to go into secondary school teaching or industry.

> kid, we all are dreaming of being the best in our field, which in mathematics would mean making some stupendous discovery, or something like that. That's not quite likely for people that I know, including myself. So, what the obstacles are that we face is just trying to better ourselves. We have to get as much mathematical knowledge under our belt as possible, and try to get as much practice in mathematical creativity as possible. I think the big obstacle is probably to do a good thesis, because for the short term, that seems to be one of the major deciding factors. Your first job, for example, would depend a lot on how good your thesis is, which no one will be able to say except your advisor. So, you have to get a good thesis; I mean, a thesis that your advisor thinks is striking. Other than that, there are other things that you might consider an obstacle. You have to more or less develop the capacity to teach, because, obviously, being a mathematician in academia involves teaching. You have to get some skills in that. I can't think of any other major obstacles (Chicago male, 2354-2355).

> I think really it's just a matter of what kind of work I do. You know, it's just a matter of the quality of the mathematics that I do. Maybe that's naive, but that's my impression (Chicago male, 2034).

A similar pattern of response exists in Table 38, which shows the kinds of sacrafices graduate students think need to be made to be successful in math. Both males and females mention the amount of time it takes -- about a third each. Beyond that, males' responses cluster

Table 37

Graduate Students' Perceptions of Greatest Difficulties to Overcome Professionally

	Males	Females
	(N = 22)	(N = 18)
None	0	23
Math Itself	35	0
Thesis	0	11
Bad Job Market	41	17
Finishing PhD	5	5
Insecure about Ability	14	0
Personal Insecurity	0	23
Two Career Problems	5	0
Sexism	0	11
Seperation from Family	0	5
Graduate School Requirements	0	5
	100	100

Table 38

Graduate Students' Assessments of Sacrifices Necessary for Success in Mathematics

	Males (N = 44)	Females (N = 23)
None	7	9
Time Investment	30	39
Low Pay	18	4
Isolating Work	16	0
Becoming Too Obsessed	14	0
Social Life and Other Interests	0	31
Persistance	4	0
Personal Dissatisfaction	0	4
Academic Insecurity	7	0
Marital Stress	4	0
Postpone Children	0	4
Other	0	9
	100	100

around work-related sacrafices (low pay, isolation, becoming too obsessed) and females' responses cluster around giving up other interests and their social life.

> Well, there's a big commitment of time. I guess it partly depends on what kind of abilities you've got. And so maybe if you are just exceptionally gifted, you don't have to make such a sacrafice. I don't know. I have a feeling that everyone, you know, no matter what they've got going for them from the start, if they really want to make a contribution and be a successful mathematician, they would have to make a real time commitment. For me, I've felt a sacrafice in that my life is becoming focused in math. And, you know, it's been important to me to be aware of what's going on in the world. And, I'd like to read novels that people are talking about and see movies that people are going to see. And, you know, just sort of be a part of the culture. And, that's something I'm finding myself less and less able to do. So like in the past weeks since school's been out, I've seen four movies. Just trying to catch up on everything that I've missed for six months (Chuckle) (Chicago male, 2029-2030).

> I have known people who have been mathematicians who, I think, partly as the consequence of being a mathematician, have been very lonely and very outside the world -- who have lost some kind of touch with the world because of concentrating so much on something which is not of interest to anybody that they're

going to meet on the streets.... For being so wrapped up in this, with this foreign god almost. For being the modern maniac who looses the ability to come back to where other people are, who feels something missing or the right to have another messing up the cause and effect. I've known people who have been driven out of the world by mathematics, I guess you could say. It's a great danger. But, that's certianly not an impediment of becoming a mathematician. That's an encouragement to become a mathematician for those people (Chicago male, 1706).

If you are not a basically hard working person, and I don't know that I am, you have to force yourself to work and spend a lot of time doing stuff that gets you nowhere in order to get somewhere eventually. In some sense, it cuts back on your free time. I mean, it is not like having a 9 to 5 job. I don't think that it ever is. If you really want to be an outstanding mathematician, research mathematician, you can't just say, I'll work on it a few hours a day or something and teach the same class (Chicago female, 3045).

I think time. You have to put a lot more time into it than I'm willing to put into it, at least right now, you have to just spend time, you have to do it for enjoyment too, you really have to enjoy it (Circle female, 2152).

Time. I don't think that has anything to do with mathematics though. I mean, to be devoted to your field of anything, I

> mean the problems with doctor's spouses, right? Their whole life is their career. And, I think that in order to be good in something, I don't think you can do it part time. Now, maybe somebody can. I don't know anyone who has. I like to go. This is probably why I don't read....because if I wanted to read the book, I would want to sit down and not do anything else and enjoy the book. Right? Except somebody comes home and needs something so you drop the book. And someone else needs dinner. Then the laundry load had to be changed. Well, forget the book. I mean, because if you can't sit down and do the whole thing, then I don't want to do it at all. And I think that is my opinion on going deeply into anything. How can you go part way and be distracted? (Circle female, 5864-5865).

> Just to do that, I am having to put the rest of my life aside for awhile. I think that you have to give up other things to work on your math eight hours a day. For me, I am having to postpone having children. I can't be pregnant and write a thesis. I just can't. I watched somebody go through morning sickness and not be able to write a thesis and I know that I can't do that. Men don't have to do that. For me that is one thing that I have to give up. I think that is the big one (Chicago female, 3639).

Finally, we come to the last issue to be addressed, namely, how career and family fit together. Table 39 shows the responses to the home/work

Table 39

Graduate Student Assessments of Modes of Coordinating Home/Work Problems

	Males (N = 24)	Females (N = 16)
Unsure	13	0
Not Have Children	13	6
Will Not Sacrifice Career	25	25
Will Quit Work to Stay Home With Children	8	44
Will Share Home Tasks With Spouse	29	19
Delay Family Until Career Established	8	0
Daycare/Family Help/Staggered Schedules	4	6
	100	100

coordination questions. One-fourth of males and females say they will not sacrafice their career for family. Beyond that, the biggest difference is that five times as many females as males (44% vs 8%) say they will quit work and stay home with children. Again, let's look at the quotes.

> Well, that question is, you know, very theoretical. When the time comes, I'll have to figure that one out. I guess I'd like to have kids and work as a professor and have the summer off. Just sort of a normal type of life, I guess. Well, I've always felt that I wouldn't be opposed to changing diapers and staying around the house as much as possible. I like kids; I like children. So, you know, I would do some of the cooking and cleaning, whatever (Chicago male, 2071).

> Well, she wants to be a mother at home. At least, probably, until the kids are off to school. And I think that it's best for the children just to have, you know, at least one parent there. And she wants to be there, at least now she says she does. I think that if I get the kind of job that I want at a small school where I would be able to teach, I would have a fairly flexible schedule. And if she wanted to, I'm sure she would be able to work part-time and be able to arrange something like that (Northwestern male, 4451).

> I don't have any plans to get married and have a family or anything like that. (Would you eventually want to?) Oh possibly. (How important is having kids to you?) It's not terribly

important. (What compromises would you be willing to make in terms of if you did have children?) Well I think, the kind of thing I tend to think of when I think of working and having children I would not want to work and have children alone. If I were going to have children, obviously somebody would be the father of the children, bla, bla, bla, and I would expect him to be around. I would make half the sacrafices essentially. There's some interesting things going on with split jobs; two people taking one job, that kind of thing and that would be the kind of thing I would be willing to do (Chicago female, 6131-6132).

I think part of the reason that I am not sure if i will ever get married is that I wouldn't want to have to put up with anyone who would not do their fair share around the house. I mean this also in terms of if there were children. A friend of mine, who is very good about this, this guy, I was really impressed when he told me that they would not have children if he could not so his half of the work. If he couldn't help his wife. People see it as they will help the wife out. I don't want to be helped out. If somebody is not doing their half of at least a good portion, then I am kind of not interested. I am not particularly interested in taking care of someone. With children it is a different story. But adults, I'm not interested in doing it (Chicago female, 3050).

Summary for Chapter V

This chapter has presented data pertaining to sex-comparative processes in graduate education in mathematics. We showed that male and female graduate students do not enter graduate school on equal footing. Males begin their graduate training with more focused orientation on mathematics, with long term interests in aspiring to become a professor of mathematics, and with an expressed view of the intrinsic value of mathematics as subject matter. While clearly having an interest in mathematics, on the other hand, females tend to be diffuse when beginning their graduate training. Their career goals are not as specific and their motives for going to graduate school are not as focused as those of males.

Once starting graduate school, males define their major problems in terms of the work of mathematics, whereas females define their problems more in terms of social relationships, and males tend to put in more hours studying mathematics. Males identify more with the faculty and tend to interact with them on a more individualistic and task-oriented basis. Females are more likely to identify with family and friends and their style of interaction with faculty is one centering on learning math in the organized classroom format. Males are not only more likely to know about sponsorship by faculty, but they define the function of sponsorship differently than do females. While females think of it in terms of receiving special attention and nurturance from faculty, males think of it in terms of instrumentality and career pay-off.

This instrumental attitude, revealed in the interviews with the males, carries over into their career approaches. They show a greater specific orientation toward wanting to be a professor of mathematics, and the obstacles they perceive in their careers are defined in terms of work. Females tend to define perceived obstacles in terms of interpersonal relationships, and correspondingly, they define their major sacrifices in terms of giving up outside interests and social relationships. Moreover, like the pattern of responses for the undergraduate females, they envision problems of coordinating home and work responsibilities when they finish their formal education, although a higher proportion of the female graduate students than the female undergraduate students state thay they would not sacrifice their careers for a family.

CHAPTER VI

ANALYSIS OF THE DATA - III:
FACULTY

This chapter presents data from interviews with the faculty members in our sample. These data also are organized longitudinally, and include sections on the backgrounds of their becoming mathematicians, the work of mathematics, the social worlds of mathematics, and career paths and contingencies. However, our findings are not presented in quantative form because the interviews were not as structured as those with the undergraduate and graduate students. Faculty had less time to devote to being interviewed, and, in fact, had more control over the topics of the interview than did the students. Thus, without the required uniformity in the response categories, quantative tabulation of responses could not be accomplished. We offer instead a qualitative analysis which is heavily grounded in direct quotes from the interviews.

Educational and Family Paths to the PhD

Given that the faculty have a high degree of occupational commitment and that all our faculty respondents, except for one, have a PhD in mathematics, it is interesting to note the variety of modal experiences in their educational backgrounds. Sex differences appear in the pacing and timing of educational careers, with women having experienced greater discontinuity than men, but it is clear that even for the men there was variation. One of the professors at the University of Chicago illustrates such variation.

> You weren't forced to go to class, for instance. After awhile I really didn't go to class very much. I was bored. I was bored as an undergraduate mostly, except for my senior year. The courses I found boring and not very challenging....we used to sit in the common room playing cards or I used to shoot pool. I was very bored, except for my senior year when I had two very good mathematics courses and a very good one in physics. Not by particularly good people, but inordinately good physicists (6311).

Having become very excited by mathematics, he was no longer bored in graduate school, but he still managed to fill his life with other activities.

> I hustled pool at the time. I used to bet on horses and loose my money and I was courting my first wife. That was keeping me busy (6316).

He told the interviewer that he almost quit mathematics during his first few months of graduate school, but one of his professors became a very strong and influential force in his professional life which induced him to continue.

Another male, an associate professor, illustrated this same drift pattern. He characterized his educational experiences in the following way.

> Academically my high school grades were perfect and my graduate grades were perfect. My undergraduate grades were terrible.

> As an undergraduate I just sort of played a huge amount of bridge, chased a lot of girls, did a lot of intramurals, ate pizza, and just had a good time. (Did you have a lot of friends?) Yeah, a lot of friends, it was a lot of fun. (What were your graduate school years like?) Quite nice. Very, very hard-working. I just worked all the time, getting A's all the time. My friends were all through the math department and some in the sociology department and my wife would work all the time too, and on Friday nights we would go to the Hyde Park Theater or something, go out a little bit, very occasional fighting and otherwise just work. I was very nice (6281-6282).

Still another, who had received all his education at Harvard University, describes a rather sharp contrast between his undergraduate and graduate years. He first majored in physics as an undergraduate, but says that when he started taking math courses, "I just loved it. So that was the end of my physics career." He describes graduate school, however, as terrible, unpleasant, and unhappy. Instead of withdrawing from mathematics, though, he withdrew from the environment of the graduate department and his advisor.

> I really disliked the atmosphere and talking to people so much that I basically didn't talk to anybody. I wrote two-thirds of my dissertation before my advisor knew what I was doing, because I didn't enjoy talking to him. I just found it unpleasant. The whole atmosphere I didn't enjoy.... and reacting to it particularly by basically withdrawing and

> saying Ok, I am going to do this by myself if I have to. I don't necessarily look back at them as mathematically wasted years, but I don't look back at them with fond memories (7871).

Variation in educational experiences were of different types for the female faculty. An associate professor at DePaul University, for example, described her work patterns during her undergraduate years as involving rather consistent levels of work and time commitments. However, she had insecurities and doubts about mathematics and about what she wanted to be.

> I was a dorm counselor where one counsels incoming freshmen -- you know, for a couple of weeks. I was fairly studious in college. I had been in the band in high school, but wasn't in college because I felt that I wouldn't have the time. Well, it didn't appear to me that was true, but that's what I thought. I studied a fair amount of German because I was going to be in Germany. Some of those years, you see, was actually spent really not doing any math at all but doing a lot of German and history and that sort of thing. You know, it was actually in Germany. In graduate school the first year it was mainly, you know, getting back into the classes and working hard and getting into the swing of things. The second year, there was course work in preparing pre-lims in the spring of my second year. And those were the big exams which essentially meant for us that at that point the course work was over, and you would qualify for the exams and come at the end of the first year. So, for the pre-lims over three or four

> months I just did nothing but go to classes and study for the pre-lims (6156,6170).

Another associate professor of Northwestern University never had any doubts about what she wanted. "I studied a lot, but I like to study, so I did what I like." After two years in graduate school, in which she worked very hard, she quit to become a full-time housewife and mother. After her youngest of three children started school, however, she re-entered graduate school. During that time, she focused almost entirely on her work.

> I just worked very hard, I really worked. You give up a lot, and after I went back and made the commitment, I loved it. You just make the commitment that you're going to give up a lot of other things. I put my time in on work and on the children and that was essentially all I did. I am not a very social person from lots of points of view. I certainly don't mind giving up going to parties in order to, because I found that I had to work a lot, but I must say that I regretted giving up movies (6525-6526).

Still another form of variation for women can almost be called an avoidance pattern. One of our women faculty respondents described her undergraduate years as "possibly the most active intellectual life that I ever had." As a married graduate student, however, her intellectual life became more diffuse.

> (Were days mainly spent studying?) Some of them. I also cooked and you know went shopping. I mean I went shopping for clothes. When I got married we had more money that I had ever had before because my husband's family had a fair amount of money. So we were a little bit richer than I had ever been. And since we both had graduate incomes plus some money from his family, I bought clothes. I can't say I was terribly studious, but I worked (6694).

In addition to the kinds of educational experiences our faculty respondents had, there is the matter of the actual decision to pursue mathematics and the degree of family support of that decision. Although sex differences appear, for the most part the respondents stated that their families were supportive and helpful in their decisions. First, the women faculty.

> (What did your family think when you said "I'm off to Brandis for a PhD?") Surprising as it sounds they went along with it fine. I can remember my mother and father went up, drove up to Boston with me and let me off in a room that I had rented, and they went back to New York. I remember they were very supportive. (Did they ever say anything like "have you thought about getting married?"). No, no (6540).

> (Your family, what did they think of this graduate school in mathematics?) They thought it was fine. They liked the idea. I don't think my family had much influence one way or another

> except insofar as, well, first of all they certainly encouraged scholarship generally, as did most Eastern European Jewish families. On the other hand, one aspect that may or may not be relevant, the studies that have to do with women who are successful, I don't know if it has something to do with science or if it's in general, but at least in the sciences it seems to be a correlation with identifying more with the father than the mother and certainly my major involvement was with him (7951-7952).

The next quote, however, shows that such support was not always unqualified.

> (What was your father's reaction to your interest in mathematics?) Well, he disliked that I was going to college at all, so it wasn't much worse doing mathematics than going to college. (Even though he disliked it he let you go?) Yes, after much fighting, he wanted me to drop out of high school after 10th grade because that's what most girls did. I always knew I had to be much better than my brothers in order to have the slightest chance to be able to continue (6979).

The male faculty also describe family support in positive terms.

> They were supportive as always. They've always been supportive of everything (6282).

> I guess that the only thing that they were concerned about is that a lot of people make a lot more money than the academic mathematician. And I think that they were reasonable. I mean they mentioned that (7865).

> By that time my mother had given up on the fact that I was going to be a doctor, and my father was delighted. He would have preferred that I went into philosophy, but he was very delighted that I would end up an academician (6315).

While family responses to the decision to pursue mathematics were rather evenly supportive, there are clear differences in the kinds of messages our respondents were receiving from their families when they were growing up regarding what and who they should be as adults. Males were encouraged if not pushed towards the professions; females were encouraged, sometimes subtly and sometimes overtly, to do what most females do -- marry and raise a family. Consider, for example, the following account of a male professor. No mention is made of a concern about his marital plans.

> They were very achievement oriented at least in regards to intellectual pursuits. My mother obviously wanted me to be a doctor, she couldn't understand why I didn't want to go to medical school. My father's attitude was the more abstract of things I would go into the happier I would be. He was happy with the fact that I had gone to become a mathematician (6310).

The concern about marriage typically appeared in the dialogue between the female respondents and their parents.

> The advice that I had from my mother was to take typing and shorthand so I would have marketable skills. So I did my college prep courses on the side. I don't regret it, but I never did use it, so it was probably a waste of time. I should have spent more time on a little better background for college, but neither of my parents were college educated so they were very practical. Their ideal earning a living for a woman was to have secretarial skills. (Were they very thrilled when you were the first in the family to go to college?) Yes, I'm sure even greater when I began teaching at the university level. I think my father was very happy; my mother wanted me to be a lawyer (6799).
>
> (What did your family think about you going to graduate school in math?) I think my father must have approved or fairly much, I don't know. They certainly didn't give me a hard time. Maybe my mother started thinking that I should get married or something (6693).

And sometimes that dialogue takes the form of blatant discouragement and blockage of career aspirations.

> I wanted to be a physician for a very long time, but my father was strict. He was a teacher so he decided that each of his

> kids was going to be a teacher. The only way I could have gotten away with not doing what he wanted me to do would have been to run away from home and go some place where he couldn't find me. And I didn't go that extreme. (What did your mother want you to be?) She didn't say anything. Anything was Ok with her. Well, she didn't have much to say. (Did you ever tell your father you wanted to be a physician?) Yes. (What did he say?) You're crazy. As far as women are concerned you were not supposed to be able to do that, and if you said that you were almost kind of crazy. (Is your father proud of you now?) No, well he died a year and a half ago. (Before he died was he happy with what you had done with your life?) Well he wasn't ashamed and he wasn't happy. I mean a girl was supposed to get married and that was it (6975,6979).

To summarize this section of the chapter, we can say that although there is much variation at the individual level, there are two ideal typical trajectories. The common ground of these trajectories is that all respondents in one form or another had to make significant investments of time and work. They had to "pay their dues." Accordingly, these trajectories pertain to the process of acquiring the PhD from the standpoint of education and family arenas.

The first trajectory is defined by undergraduate and graduate students as studious and academically productive. This trajectory, however, has room for other activities, such as parties, hobbies, dating, and family involvement. Persons in these trajectories are embedded in mathematics as an activity and form of work, but their lives are not defined or dominated by it. The second trajectory involves students who are not as serious about their studies early in their educational careers, but sometime before entering graduate school, they realign their self and work. Mathematics becomes their life in graduate school. They become more serious and industrious, work constantly, and pay little attention to other arenas of life. While certainly there are combinations and variations between these two ideal types, and the types themselves are not exclusively descriptive of males and females in our sample, we believe that the first type more accurately depicts the trajectories of females and the second depicts those of males.

One of the factors that give rise to these trajectories is the family and career expectations communicated to sons and daughters. While the respondents were clear about the fairly high degree of family support for their decisions to pursue mathematics, it is obvious that the messages received by females were more diffuse than those received by males. The encouragement females received was sprinkled with hints of "practicality," such as obtaining useful skills for female jobs or considering more seriously getting married and raising a family. Males, on the other hand, received encouragement sprinkled with the language of achievement. They were asked to seriously consider the alternatives among professional occupations available to them. We believe these differences are important background contexts for the formation of trajectories leading to the PhD in mathematics.

Style and Meaning in the Work of Mahtematics

This section pertains to matters of how mathematics as work activity is done as well as considering the meaning that work has for mathematicians. We present data on three aspects: the aesthetic qualities of mathematics, the extent to which mathematics is seen as having an intuitive dimension to it, and patterns of work style.

The deep personal meaning of mathematics both as a form of work and as a life career was brought out in the clearest terms by one of the male professors in our sample.

> I'm in it because I love it. You don't slip into mathematics. In other words, you don't choose it as something like, well, I guess I'll be a mathematician. Nobody ever says that. Some, you might say, Oh Christ, I'll get a job at the bank. But you don't say that about mathematics. At least, when one starts it, they start because of an overwhelming or strong interest in it. Some internal feeling that you can do this. This is something that you can do, that you're good at. You know, of course, what happens is that a lot of people along the way suddenly find out that....at some point the kids who were very good in arithmetic get into high school and never get through geometry. They can't do it. It's very discouraging. More than likely, somebody will be very good who wants to be a math major will be very good in high school, get to college, take a year or two of calculus, and then get into something like group theory. And we have more people who fall by the wayside that suddenly discover that there's this level of abstraction that is beyond them. And, then, they sort of fall by the wayside. But I think in each stage that a person continues, they continue because of their feelings, generally speaking, because of the feelings about the beauty of the

> subject, or their ability to do it, and then, the accomplishment. There is beauty there (7935-7936).

The aesthetic quality of mathematics was mentioned in quite a number of our interviews. In fact, the majority of our respondents agreed that math had an aesthetic quality; none denied it. Some, such as the professor in the previous quote, expressed their feelings in a very passionate way.

> It's fantastic. It's a high to prove a theorem. If you're working on research and you get the answer to your question or get the proof to work out, ah, there's just nothing like it. If you work hard enough and think hard enough, the answer will come and even more so in research, because if you're doing original research then you find out something that nobody else knows. That really is very nice. Part of the aesthetics of mathematics comes from just working with very basic things. You can trace what you're doing back to a few axioms, and you know it's correct. If you've done it correctly, then somebody is not going to say tomorrow that what you did today is wrong, that it stays right, and it's not subject to how people are feeling on a given day (6065-6066).

> (Is math aesthetic?) Well, you could say in a way it's like.... see I don't mean the kind of mathematics where you use a formula and plug in numbers. I don't really like that kind of mathematics. It's the kind of mathematics where you kind of investigate mathematical structures, mathematical spaces, and how they fit

> together. It's like a beautiful building. More so when I was young, than now, why certain things are like what, like how in the universe things fit together, why they are like that. And, what at first among other things drew me to mathematics was that mathematics could explain some of those things. But also, the beauty of structures. Why certian functions of equations didn't work out. Why they were not solvable. Why certain things had certain very strange properties, and if you go a little bit deeper into the structures of limited, not general spaces, you see that that's part of the whole new mathematical building. And I found that beautiful. (Is there any other way math is aesthetic?) Well, if you call that aesthetic, it's one nice thing about it is that it's completely logical. You can't bend it according to your opinion. It forces you to be honest. If you want something to be true you can't bend a few arguments to make it true. It's not possible, no matter how much you want it to be true. If it's not true, that it. You have to be completely honest. You can't be the slightest bit dishonest (6971-6972).

In addition to that aesthetic quality, the faculty identified having an intuitive feel for math as an important ingredient for becoming a good mathematician. What varied in their responses was the intensity and degree of importance attributed to intuition. Exactly what math intuition is and who has it was not agreed upon. Two types of intuition are identified by a professor in the following quote. One type pertains to how to do problems and the second pertains to how to identify research problems.

> The geometric intuition is something that is clear to me some people have. That means that they have an ability to visualize geometric objects better than other mathematicians. There are other mathematicians who can look at a tremendously complicated formula and write an answer. It's just that they can piece things together in the head. Now, this is some kind of intuition or mathematical ability, but there's other kinds of intuition. The intuition to try to determine which kind of problems are going to be important for future research in a particular area. That requires a certain amount of intuition. What was that based on? It's based on experience; it's based on feel. It's not to question there is usch a thing as mathematical ability however. That's undeniable (7928).

While the nature of math intuition was not always agreed upon, however, the one dimension upon which there was fairly wide consensus was that it involves intuitively knowing an answer to a problem or knowing how to obtain the answer.

> You have some idea of how to do something. I mean, if you're presented with a problem, you have some intuition about it. I means you have some ideas of how to approach it, some idea of whether it's right or wrong (6204).

> Just a lightbulb, just knowing what's true without actually having it in front of you, the proof that something is true (6552-6553).

> Just knowing a lot of math from a lot of theory and being able to bring it to bear (6299).

> Math intuition is when you solve a problem and just have the intuition for a good way to solve the problem (6418).

> Intuition just means essentially being able to get the feel of what's happening. Essentially having a sense of what's true. It's not necessarily knowing why it's true (7963).

> Some image of what should be true, somehow divorced from the concrete symbolism of writing it down on a piece of paper. It's almost a way to think (7885-7886).

How important is this intuitive quality for the work of mathematics? For some it was important and based largely on experience, but it could not be evaluated independently of other factors, such as hard work or interest in mathematics.

> Intuition may be part of one's mathematical ability, but it is clear that certain people have intuition about certain things in mathematics. Not just mathematics, in general, certain aspects of mathematics. You know, that is very

unusual and distinguished from other maybe less talented or less gifted people. But the name of the game in mathematics, like almost any pursuit, is sweat. The fact that some people produce better mathematics than other people means they probably have more ability. But they are working their asses off. They could have all the ability in the world, and if they didn't really sweat, they would be in trouble (7925-7926).

Intuition comes with experience, and it is very strongly connected with math interest and hard work. This is my feeling, and I heard of it from a very good mathematician, very well-known mathematicians. They think that 99% of mathematics is work and 1% is what you would call idea or intuition (6387).

(What's the basis of math intuition?) I guess being brighter, just having worked out enough problems where I could have some idea of what it's going to turn out to. (How important is it to doing mathematics?) I wouldn't say it was critical (6204).

Intuition is partly something one develops. I mean, if you know something very very well in some area, you develop a kind of intuition about it. So I guess it's very much developed (6213).

(How do you get intuition?) I suppose for some people's definition that intuition is something that you just are born

> with or it's just natural, but I have a feeling that from my point of view that's not true, that there's a whole lot that you acquire -- experience -- and after awhile, especially in mathematics, you sort of mathematically sophisticated. You've got built up a background and you just get a feeling for what should be right and what is probably an incorrect statement, and you may get some surprises but you can sort of go along with that. (How important is intuition?) Oh well, probably very important. In research it probably helps from just plodding along when you may get there eventually, but I think if you have a little intuition you may get there a lot faster (6553-6554).

Other respondents saw intuition as very important and as knowing what you have almost by instinct.

> It's very important. It's probably the most important factor. Without intuition there would not be mathematicians. Everything else is just publishing the thing afterwards (7862).

> I know a lot of people who just never studied a lot. They have a good intuition for it. If you have intuition you can solve 90% of the mathematics (6418).

> Intuition is almost not just important, it's really fruitful. I mean you can look at it and say, well that is true. And have some vague image as to yes why it's true -- somehow see

> why it has to be true without really having it in your hand (7856).

One respondent addressed how intuition is seen within the very best mathematicians.

> The very best mathematicians, of course, have everything. I mean they work harder than anybody else and they have this mathematical intuition. I mean, it's sort of a combination of working hard and intuition. And in different people you have different mixes. I mean, some people just won't give up and they'll get somewhere whether they know what's happening or not. (Can hard work make up for lack of intuition?) Oh yeah, to a large extent. It sort of depends on the level. If you want the absolute very very best, then you just have to have everything. Luck too. I mean the very best results are a sort of confluence of a man who is willing to work very hard, who has some brilliant intuitive insights, and who just happens to be in the right place at the right time (6299-6300).

Almost all the respondents stated that male-female differences that might exist in math intuition were the result of socialization or differences in experiences that boys and girls have with mathematics. The following quote, however, expresses a somewhat different view.

> There is no question about it. They (girls) usually are thought of as having less intuition by most male mathematicians. On

the average anyway. One thought that I've had, which seems to have some validity, is this thing that women for the most part tend to be very meticulous. They go step by step and everything has to be just so clean. They tend not to look for the big picuture, to see some big messy object and then try to untangle it. Instead they will try and go piece-meal at the problem, step one, step two and step three. But I don't pretend to have any special insight into that. I actually suspect that a lot of this is a pure reflection of the way they've been raised to do things as little girls, to do things very neatly, to put a clean dress on, all these horrible things that are done to them mathematically at a young age. But there are certainly counter examples, spectacular counter examples. I know one. I know that I tried very hard to keep that subject away from undergraduate students. I'll never discuss it with them, but it certainly is something that I always notice in my classes too. A pattern emerges. The boys tend to be messy and rough, and, well, the bad students are all equally bad, nothing to distinguish them, but the good students, you get boys who are very messy but they can see what they are supposed to do, whereas the women it seems chip away at things very slowly and the good one are extremely efficient, very efficient and especially in courses where there's a lot of manipulating and learning the steps that connect. Whereas boys are definitly as good as that, the women are never as good as that kind of orientation (7063-7064).

Our faculty respondents spoke fluently and with conviction about the aesthetic and intuitive dimensions of mathematics, both of which pertain to personal relationships between the mathematician and his or her work. Another aspect of their work that they discussed was the style of work -- specifically about the extent to which mathematics was a singular and very individualistic kind of activity or a collective and group-oriented activity.

The degree to which a collective approach to mathematics is appealing, enjoyable, necessary, or productive is reflected in the following series of statements.

> I do a lot of work with people. So it can be done. I think in order for it to be done, though, you have to have the right ingredients and that means you have to have two people who are not only working on the same problem, but who speak the same language -- the same internal language. Like my advisor and I, we literally think the same. And this fellow in Sweden is also the same. We think exactly alike. If you give us the same problem we'll say do this and this, draw this picture, and put us in three different rooms and we'll draw the same picture. While someone else would say, "well, you're supposed to do this and this." Any approach might work, but actually I don't think that collaborative work is that rare. That's not my view of mathematics at all. At some level it is singular, and so perhaps my example proves the rule (male; 7064).

> I just worked by myself one time. It is impossible for me. It is easier to work with others; not only easier, but it's also necessary to work with other people. If you don't think you can solve one problem, maybe you can solve it together. It's also necessary because if you work in a group maybe you can see more interesting questions (female; 6418-6419).

> It can be done in a collective. It's very much more enjoyable and easier if it is done with other persons. If you can discuss what you are doing with somebody else -- it's kind of a lonely thing if you do it all by yourself because ordinary people don't understand what you are doing (female; 6994).

> Lots of times people work together because it is such a pleasant way of doing mathematics in that you can just talk back and forth and hash out all the problems and details in conversation which is a lot more pleasant than working it out yourself on a piece of paper (female; 6555).

On the other hand, there are faculty who recognize the collaborative mode of work but prefer to work alone.

> I tend to do most of my thinking alone. If someone throws out a problem, I'd rather take it home, sit on it, and think about it for awhile than just right there, start talking back and forth. But I know most people, if you can talk mathematics

back and forth, and you generate ideas, and also you save yourself considerable amount of time by if you think of something and you don't know whether it's right or not and you could sit there and think about it. And there can be a very easy example that tells you that you're wrong. And someone else can come up with it right away. And then you can go on from there. I mean, I think working with people for many is very successful. And it is true that there are more single papers in mathematics than there are in a lot of fields (female; 6265).

I am not sure that it is not really more sort of the nature of the subject, rather than the degree of specialization. I don't believe in degree of specialization at all. It's just part of why I have not been particularly collaborative on papers (male; 7890).

Oh certainly. Most people who aren't mathematicians think mathematicians are strange. I haven't collaborated with people very much, but mostly because I've never had anybody who was interested when I was interested. I think mathematicians often work together. Not as often, maybe as in other fields, but they do. It's simply being independent and rarely thinking about some thing as someone else. And not being willing to drop what you're doing and go do what someone else is doing just for the sake of companionship. Mathematicians do work together, however. The point is that there's no need to work

> together like there is in an experiemntal field, where you really need more people working (female; 6733-6735).

> I think collaborative work is done. And I have done some. I did not do any until fairly far along in my career. I don't know that it's really a question of being difficult. I'm not sure what the process is. I think that's difficult. Some people tend to do it much more readily than others. It has alot to do with personality more than anything else. Some people are very secretive about their work until it's published. I have a sense that they think that someone else is going to take it or steal their ideas. That's one extreme. And the other extreme is people who just go out spouting ideas, tossing out ideas all the time trying to get other people to respond to them and get something together. And then write a paper about it. I tend to think better when I'm not in a social situation. If I'm going to really concentrate and think about something. The collaborative things that I've done tended to be talking about a problem and then I'll go off and think about it. And go back to the person and say look here's what I figured out. And then, they would say something, or maybe they would have figured out something else in the interim. And gradually put the thing together (male; 7120).

While it certainly is true that both female and male faculty are found to embrace both the singular and collective style of work, the collective mode seems to be found more among the women. Working with mathematics is described as necessary, pleasant, and less lonely by women who favor the collective approach.

The collective work that is described by males involves working on the same topic and idea, but co-presence is not necessary. Females, on the other hand, are more likely to discuss collective work in terms of physical co-presence. This difference suggests that sex differentiation in the collective style involves males who emphasize the term "working" in working together, and females who emphasize the term "together" in working together. So while there will be males and females who fall under both categories, the general rule is that males emphasize a focus on the same ideas and issues, and while females recognize the need for common intellectual foundations and concerns, they emphasize actual face-to-face interaction.

Students and Colleagues of Mathematics Faculty

This section contatins data on two topics which are quite important to our study. The first pertains to the realtionships the faculty have with students, particularly role modeling relationships; the second pertains to relationships among faculty, especially those of recruitment of new departmental members and networking. These topics bear directly on the issue of the perpetuation of mathematics as an enterprise.

In chapters IV and V, we discussed role modeling processes from undergraduate and graduate students' points of view, respectively. Here we examine those processes from the faculty viewpoint.

Most of the faculty understood the concept of role model, and defined it in terms of emulation. For example,

> I guess I would say they like you personally and they've seen that you made a success out of your life, and they would

> like to emmulate that (female; 6252).

Perhaps this role modeling by "exampling" is an optimum attitude on the part of faculty, but some feel pressured, distainful, or self-conscious about the process.

> Role models for students. Yes, in fact, you know, it's obviously something that's always pressured on one. So, of course, for me, it's something that you just put up with (female; 6726).

> The concept of role model is a little bit foreign to me. I don't like the idea. I guess I don't like the idea because it sort of feels like....I mean if I were a role model then in some sense I'd feel like it would be interferring with the sort of normal development of somebody else (male; 8008-8009).

> Once you find out then you, sometimes, you begin to watch what you're doing (chuckle). Until after the relationship has already been established. When I was younger, I remember someone had mentioned to me that I was a role model for somebody else. And then I began to feel self conscious (female; 6253-6254).

> I just teach them and talk to them and I'm not going to worry about my role as a role model (female; 6550).

> A role model is sort of like a student aspiring to be something

> like a faculty member. I somehow just don't see myself so much in the role of role model (male; 7021-7022).

> I have no sharp perception of myself as a role model. That's up to them. If they want to choose me as a role model, that's fine (male; 7916).

> Role modeling means they should want to emulate my lifestyle and professional pursuits and so forth. I think almost no graduate student should do that. And I think some do, and I think it's to their disadvantage to do so. I think they should develop their own talents (male; 7917).

While quite clearly a number of faculty felt uncomfortable with the concept of role modeling and felt it was not necessarily a benefit to students, another portion expressed their willingness and sometimes enthusiasm for being a role model.

> (Are you willing to be a role model for your students?) Of course. They need to see more people who can combine children, I think especially, and any sort of career. And in somewhat of a successful manner. (Do you think you can be a successful role model for your male students?) I think I'm more likely to be a role model for my female students. I don't see any reason why I wouldn't be able to be a successful role model for my male students also. Probably they would see themselves more

in terms of two people who have a family and both have careers, so I can do it too, if I want to get married and have a family rather than just seeing me specifically as a role model. (Can male faculty members be a role model for female students?) Well, the same way that I could be a role model for the male students. I mean I think of myself as a role model primarily for people who want to have a family and who care a lot about their family and want to have a career. I mean, there's no reason why I couldn't be a role model and as just someone who like mathematics also (female; 6254).

(What you're saying is it's not the role model that so much comes to mind, but sometimes you see yourself as how to motivate or how to coach someone?) All the time, with every student I have to sort of decide what would be the -- what's the best way really to deal with the student. Getting the most from a student. Encouraging the student, getting the students through, and so forth. (This is not what you would characterize as being a role model?) No, not at all. Now obviously I've had a personal influence on a lot of students, but I don't think I consciously go about trying to do this. Obviously one influences another. It depends on the student. I mean I've had students who I really enjoyed being with and we became friends very early and obviously with them I've had a great deal of effect. Some others probably less (male; 6332).

> Well I like the students to capture my enthusiasm for math. I want them to do and enjoy math and I try very hard to convey my enthusiasm and my enjoyment. I mean I think I'm pretty good, and I mean I don't fake it (male; 6297-6298).

Just as there is variation in the degree to which faculty are willing to be role models, so is there variation in attitudes about cross-sex role modeling. Those faculty who held negative attitudes toward the process tended to think it didn't matter what sex was involved. Those who held more positive attitudes tended to think that cross-sex modeling not only was possible, but in some instances necessary.

> I've become convinced that the role model of a woman faculty member for female students would be important (female; 6326).

> I don't know if they're quite as effective in terms of a role model as a whole lifestyle. We certainly have male faculty with female students and vice versa, and I think that they are probably as effective as far as any thesis requires. I think there may be some tendency for the female students to go to female faculty members. Well, I just think of a few cases I know where girls have gotten their PhDs. One got her PhD in philosophy here and one I think is getting hers in a year or so, and both of them are working women. I suspect there is some tendency for the women to work for the women. On the other hand, I know of one of the better female graduate students who

> is working for a man. I think maybe it's a disappointment a lot of the times toward women. Maybe in some sense they serve more as a role model (male; 7024).

> I think that females do mathematics the same as males do. I don't think they have any different approach -- that it cuts two ways. I don't think they have anything to bring to the field that isn't already there. On the other hand, I don't think that they have to consider themselves as thinking differently from male mathematicians. They do it the same way. That's it. And so from that point of view -- the doing mathematics -- the males can certainly serve as role models to females and vice versa. And the same goes for teaching. If somebody is really good at something, you want to see how they do it. And it doesn't make any difference who they are (male; 7919-7920).

In sum, while female faculty tend to express somewhat greater willingness to be role models, the overall pattern for all faculty is a passive approach to modeling. In fact, some find the notion distasteful as a style of relating to students and dysfunctional for student development. When role modeling does occur among males, it tends to pertain to work activities. Anything involving personal lives tends to be serendipitous. When it occurs among females, it tends to encompass the personal realms of life. Few female faculty, however, actively seek female students for whom they can serve as lifestyle role models.

The next section of our report pertains to relationships mathematicians have with others within the world of mathematics. In order to explore these relationships we will examine how the mathematician perceives of and participates in departmental recruitment and the network system within mathematics.

There was little variation in faculty responses to questions about recruitment practices and policies. All stated that a candidate's qualifications are top priority. Most further agreed that, all things being equal, it was a good idea to encourage the hiring of females. One male professor went even further and stated the following.

> The last tenured woman in this department retired in 1946. I would say this bothers me. I happen to feel that we should have a woman in a tenured position and I would say that even if she weren't quite as good as a male you would hire, because we have female undergraduate students and I feel that they need a role model (6325-6326).

A female instructor, who would like to see more females in math but questions affirmative action programs, explains her position.

> For the most part girls' interest in mathematics is discouraged from the very earliest stages. So how do we change this? The problem isn't where a woman goes and gets a job. It's not there that's the problem. It's much earlier. I mean affirmative action and those kinds of things may improve the situation. They may eliminate some kind of discrimination at this stage. But it's not going to change very much. If there's discrimination

> against women at the point where they are going to be hired, this would help to eliminate this problem. But it's not going to change substantially the amount of women mathematicians (6381-6382).

Another female professor believes that affirmative action is a good idea for women, although it does not work.

> (What do you think about affirmative action?) For women it's certainly a very very good idea, but it doesn't work at all. There are no women in most of the really top departments. And I think that affirmative action hasn't worked. And I don't see that it is going to work. And it also is the problem that sometimes women in sensitive jobs really get caught in it because, I mean, if you're an instructor in a fancy department like Chicago or something, and somebody makes a fuss about affirmative action, you can only get hurt. I mean, the person involved can only get hurt in that situation (6720).

Another female associate professor, who believes that a mathematics department should be fifty percent female, told us that her chairman is very much in favor of more female faculty because they are more cooperative and work harder than men, although, she states, "he just hired somebody for next year who is a man and that's fine" (6203).

A tenured professor expressed a rather different point of view.

> The point that I wanted to make to you, it's a personal perception or evaluation of the situation at the really top departments

with occasional exceptions. I don't sense much resistance to females or any other minority group, whether it would be ethnic, sexual or whatever. The fact is that people make their evaluations on the basis of quality. That's not to say that there aren't prejudices. There are. But overall, I detect these people who are good. They evaluate others on the quality of the other's work. And further down the ladder you go, the less this becomes true. And whether this is because people feel threatened or because of their own level of competence or what, I don't know. But if you scale down several levels, you will start to get considerable resistance to women in mathematics. Like, I don't want to gloss over the situation at the top level, but I think people are much more inclined to evaluate under terms of quality. My feelings about affirmative action are I think that we should make every effort to hire any one of the people from any one of the numerous minority groups. But only if they satisfy all the criteria that we would ordinarily make in any appointment, in which case we'd want to hire them anyway. So affirmative action is a moot point as far as I am concerned. The department as a whole should concentrate their major efforts on faculty development. Graduate education is important, visiting programs, seminars, are all important factors. But nothing comes even close to faculty development. That's where the concentration of effort should be. And every member in the department should be seriously interested in the department as a whole. Not just their own field, but the department's

> development of faculty because that's the name of the game. We'll take anybody we can get that contributes to faculty development (7914-7916).

The following represents the perceptions of a female associate professor who was once the only female member of the department but currently has five tenured or tenure-track female colleagues.

> (What's it like being a female in a predominantly male department?) Well, right now it's not the way it used to be when I was the only female. I felt a little bit strange. Well, it's probably my own personality. There are some things that I feel not free to talk about with males. Some things, say, if you have a problem with kids or something like that. It seems like there are some problems that men don't have. So they wouldn't know about it. But with female colleagues you can talk about them because they have the same problems. (Are you happier with female colleagues than you were when you were the only female in the department?) Yes, definitely. I mean, I don't want to say I am happier with females than males. I am happier if both are there. (What do you think of affirmative action?) It has advantages and drawbacks. If you carry it to extreme and hire people that are less qualified on the basis of sex, race, whatever, that can be bad for the institution. And also for the female faculty members because then people will suspect she's not so good. Well, if you are very careful and sure you don't hire anybody in spite of lesser credentials, a tiny bit of being conscious of it could

> open your eyes to female candidates that are qualified (6988-6989).

One of our respondents (female associate professor) sees the issue of who gets hired and the recruitment process in general in terms of networking.

> I'm sure others make sure that they have looked at all the applications of women. I mean, people are not overlooked because of what happens in this hiring process, and it's becoming clearer to me, you know, we have a box full of, say, a hundred and fifty applications. And people become essentially sponsors of certain candidates. Somebody has written them a letter saying they have a student getting out or something. (Do you see men working at the grass roots level here?) Yeah, to a certain extent. (Does it work as well for females?) Well, we're hoping. I think it has. It's becoming more effective. I think the women will be just fine if their applications can get seen and pushed with the same vigor with which the other applications are (6203-6205).

When the data are examined there appear differences between males and females in the nature of networks. The males have overlap between personal friends and professional friends; males also tend to acquire and keep friends and colleagues from their graduate school years. Females, on the other hand, tend to have networks based on personal relationships.

> I'm fairly friendly with a couple of men mathematicians but not real close personal friends (female; 6714).

When females talk about keeping in touch with people from graduate school, they are not necessarily people who are in mathematics.

> (Do you keep in contact with any of the graduate students you knew in school?) No, not any more (female; 6371).

Another female instructor never spent much time with mathematicians while in graduate school. When asked about those from graduate school with whom she has kept in contact, her reply was:

> One is a female who is no longer a mathematician. And then, the other is a male (female; 6249).

When asked about keeping up contact with peers from graduate school, another female professor responded in the following manner.

> I mean, I know what happened to a few of them. (Are these mainly females that you know what happened to?) Yeah. Because the females are much more visible. One never finished. The girl who was ahead of me who had divorced her husband because he wouldn't let her go to graduate school is somewhere in southern California. I see her at meetings all the time. The one who transferred and who was a little older than I who had been married to the doctor, married an engineer and has some kids and was chairman at Simmons which is a girl's school for a long time. She seems very active. She's been on several of

> the joint AMS, MAA committees on women. And, so, she's around a lot. The one who was sort of my age was married to someone at Brandis and never finished. Behind me there were two girls who came in at the same time. One of them has finished and I hear her name a lot. But the other one never finished. She married a lawyer and just evaporated somewhere. The men, I only really know what happened to one or two of them. I mean, some of them have jobs at funny places. You know, at California State and Long Beach or something. And I met one who's looking to try to hire someone in a meeting once. And I personally knew very well one who's at Rutgers who seems to be one of the worst mathematicians at Rutgers. I'm sure I must have run across a few others. I think there are a lot of them still in Boston at Northeastern. And I just never hear of them, you know (female; 6710-6711).

Part of the problem stems from gradute school. In more than one case, the respondents talk about the females being in one office and the males in another. Rather than respondents defining this as systematic exclusion, however, it is often defined as the attempt of the faculty and administration to make the females feel comfortable. In addition, males tended to work in their offices and interact with one another whereas this pattern was not the usual case for females. This difference is important for matters of networking, as network building is next to impossible without sustained contact. The lack of networking among females appears double-edged. First, the meaning of the professional relationship tended to be subsumed by the personal dimension of friendships.

Males, on the other hand, are able to compartmentalize their relationships into professional and personal dimensions. Second, the distribution of graduate students into office space, how females spent their time in the office, and where they did most of their work affected networking. Thus, the sex-based ecology of the department was a condition that resulted in weak networking relationships among females. We strongly suspect that this ecological factor has disappeared, even though the patterns of time spent in student offices may not have.

One male professor discussed a period of ambiguity during graduate school and how a professor took him under his wing, got him into a Big Ten university, and put him in touch with the correct people. Another male professor discussed an equally important professional relationship.

> I started working for him by my second year in graduate school and he had me read background material for about three or four months, and then we started doing research together. And he tried very hard not to treat me like he was a mentor, but as a co-worker. I mean it was always clear that he was the guy who knew more about what was going on. He was more experienced and when he said something it went. But if he ever laid down the law it was extremely rare. I always listened. So clearly he held the reins, but they were very loose reins and he tried very hard not to make me feel that I was under his thumb in any way. He just said, "I'm going to teach you everything I know and then you will be like my son, but you won't be my son; you'll be my co-worker." It was really quite unusual. I was very lucky (7050-7051).

The following quote is from a male professor at the University of Chicago which underscores the necessity of contact persons within the field of mathematics.

> They've gone to a top graduate school and/or they've gone to a top ranked place right after the school. I think that has more influence on mathematicians than anything else I could say, male or female. I mean there's no substitute for contact equality. It's that kind of contact that makes people....boy, that contact is so important (7930-7931).

The following is an example of a female professor who acquired her faculty position at the University of Illinois-Chicago Circle through networking. However, her participation was passive as opposed to active networking.

> Yeah, a friend of mine called me up and said, "Why don't you come down and apply?" And I said, "Oh, I'm really happy with the job I've got." I said I'm at a school where if I could have picked my own program I would have picked what they gave me, so I said, "I'm very happy with what I've got. I don't really need to get another job." And she said, "Oh, you'll probably like it. Why don't you go down and try and apply here?" She said, "I'll give you the name of the Dean and you call him up and he'll give you an appointment to see you." And so I did call and I asked and so he said "I'll put an application in the mail this afternoon and you'll receive it tomorrow morning.

> You have an appointment with me tomorrow afternoon at 2:00." I nearly fell off the chair. So anyway, I got the application in the morning and filled it out and took it down and met him at 2:00 in the afternoon. And so anyway he said, "You're hired for the position" (7476-7477).

Another female associate professor who did not nurture a network after graduate school has regrets.

> I think it would have been valuable to have been able to keep a closer tie, to have more of a network, whereas the thing that did happen and I'm convinced is important right after I got out of graduate school was that a lot of the ties were more or less severed. (Why?) Partly geography. Partly, I think he (her PhD advisor) really did probably see me, and, of course, the question is why he saw me this way, but you know, more as a teacher than as a researcher or, you know, there wasn't anything wrong with the dissertation or anything like that. And I think it's very useful for people getting out if they really know they become whole-heartedly involved, you know, in doing mathematical research to be communicating with those same people preferably what they were communicating with in graduate school (6203-6205).

The Mix of Family and Career Participation

This section of the report examines how lifestyles and personal beliefs and values are integrated with the professional goals and demands of mathematics. Our focus will be explicitly on sex differences.

One male respondent describes the difference in career orientation between men and women in the following quote.

> Women worried less about failing out of graduate school. If they were doing poorly they say, "Well, I'm doing poorly; it's not the end of my world." Whereas the men would say, "My god, Oh I'm failing; I'm going to be a bum; I'm just going to be out on the streets." I think the men certainly felt this pressure that even though they weren't married, they were somehow breadwinners and they had to strive and succeed (7057).

When women are asked how they handle the overlap of home and career, some interesting types emerge. Before we explore those types, however, there is an important point to underscore. That is, women, whether married, seperated, divorced, or single, seem to have the interplay of home and work in their scenarios of the future. This is not the case for the males. As a male professor stated.

> I suspect that with women there is always the personal concern of mixing the career with the family and if they're married or if they get married about the problem of seperation (7025).

A female associate professor who has never been married claims " in the one or two instances where I almost did get married, I'm so glad that I didn't"(6136). However, she offers an interesting discussion of convergence and divergence in her family and career. Although most of the women faculty we interviewed were either married or divorced, this woman's expectations about the probability of marriage was experienced by most women in our study. Even while in school, there was the belief that marriage and the family was up and coming. This is not to say that careers were ignored; rather, careers "happen to come to pass."

> When I was in college I expected that sometime in the future I would probably get married. But, it was always sometime in the future and who knows if I'll finish. And, I did all the standard things. You know, dating all that kind of thing. And when I was near the end of college, it was clear that I was going to graduate school. So I still thought that I would get married at some point. But not yet thank you. And so then I went on to graduate school....I suppose I probably would have gotten married just because there would have been nothing else to do. I don't know. I would say between the ages of twenty-two and twenty-seven it did occur to me that the time was passing. And I probably felt a little desperate. I mean this did involve a couple of instances where there were some genuine opportunities which in one instance I cut short, thank heavens, in the nick of time and in the other instance a very serious illness was involved. So I dealt with a lot of anxiety, and actually I remember a great relief when I hit thirty because then I felt that that was my own concern (6136-6139).

Another female, an instructor at the University of Chicago, has an interesting story. She finished her PhD one and a half years earlier than her husband and wanted to come to the United States to work, so he followed her. She was a postdoctoral fellow at an Ivy League school, and he was ABD and had to look for part-time work. She was then offered a two-year instructorship at the University of Chicago; her husband, having finished his PhD, followed her to Chicago. He found part-time work in industrial research. When both went on the national job market they tried to apply to the same geographical areas. However, this was difficult. Her husband was offered a good job at the University of California at Berkeley, but she found no work in that area of the country. She was offered an assistant professorship on a tenure track line at the University of Minnesota and he took a postdoctoral position at that university. When this woman was asked how she felt about marriage and family while she was in college, she responded.

> I guess I didn't want really to marry and stay at home. I wanted first to have my profession (6342).

When asked if she and her husband want children, she answered in the affirmative. When asked how she will coordinate children and a career the following is stated.

> I guess I would like to take care, me and my husband. I would like that my husband and I would take care of the child for a period. I don't know for a few years I could work a half day each. I don't know anyone who shared their work really from the start -- from the moment that the children were born. This

> is something that I'm thinking about, but I don't have any good answers because I'm thinking of my profession and it's not applicable to all professions. So I was thinking that we can take care of the child half of the time. I would take care half and half of the time my husband. But as I say, I don't know anybody who did it, and I don't know how it would be if we do it at the end (6378-6381).

The next three vignettes describe husbands and wives who both have (or are completing) their doctorates. One involves a wife who left graduate school after the M.A. to take care of the children. Another involves a husband whose PhD is in mathematics and a wife who is completing her PhD in political science; both have had to make career compromises. The last involves a wife whose PhD is in mathematics and her husband's in psychology. She has followed his career until two years ago when they established a commuter marriage and family. As of September 1981, he was tenured at Michigan State University, where she is on a tenure track.

The first couple we will discuss met while both were in graduate school on the east coast. He was one year ahead of her. Both had intended to pursue a PhD in mathematics. They married shortly after she entered graduate school. He claims she was the smartest graduate student in the program. She claims to have enjoyed school, but also got tired of working so hard at being a student. She left graduate school after the M.A. and had three children in three years. He was able to finish his PhD and pursue his career. He went to Washington University and then the University of Chicago. He also did postdoctoral work at

Princeton. She went back to graduate school, with his support and encouragement, when the youngest child was in kindergarden. She received her PhD from the University of Chicago, then she took a visiting appointment at Northwestern University and she did postdoctoral work at Rutgers University when her husband was given a position at Princeton. When they returned to Chicago she went back to Northwestern, the visiting position was turned into a tenure track one, and she was eventually tenured. Both readily admit they were lucky. She is not so sure women today could exit and re-enter the profession as she did. She does not regret putting her career aside to stay home while the children were not in school; he also feels things worked out well. When asked if she could have established a commuter marriage and family, she could not state yes or no. While both she and her husband were aware of that potential, it was never really explored. Both say it would have been foolish for him to leave his job at the University of Chicago to follow her. So while the professional and personal lives of this couple worked out, both are hesitant to recommend it for a couple in the 1980's. In a sense this couple had the best of all worlds, but how often this can occur is a big question.

The second couple have no children. He is a professor at the University of Chicago and she is ABD in political science from John Hopkins University. They met at Harvard University when he was nearing completion of the PhD and she was an M.A. Student. When applying to PhD programs, she worked within the confines of her husband's professional opportunities. By the same token, when he was explorting jobs and postdoctoral opportunities, he was confined by his wife's opportunities and choices for graduate study. She was accepted at Columbia University, which he claims was her first choice. However, she could not attend there because he was unable to secure a position in the New York area. He, on the other hand, wanted to spend time in Israel or perhaps accept a job in another geographical region of the United States. Given the dual career constraints, both made compromises. She went to John Hopkins University, not her first choice for a PhD program; he, on the other hand, accepted a faculty position at the Naval Academy, a job he disliked. When she became ABD, he accepted a position at the University of Chicago and she is completing her dissertation in Chicago. The respondent admits that he and his wife may have some problems dovetailing two academic careers, but they are open to alternative careers and both are taking into account the other's career. The respondent further admits that there may be some complications when they have children, but he believes they will be able to work things out. What we find in this couple is an awareness of the problems of dual careers and home-work coordination. This awareness is present in both husband and wife. From the data it is clear that problems, solutions, and alternatives have been discussed and negotiated between husband and wife. This is unlike the next dual career couple.

This third couple have two young children; she has a PhD in mathematics; he has a PhD in psychology. Both have and desire academic careers, but the path to this situation was very problematic. They met as undergraduates; she was one year behind him in college. During her senior year in college she was in St. Louis, while he was in his first year of graduate school at the University of Illinois. They commuted on weekends. She then decided to pursue graduate work in mathematics, applied to the University of Illinois at Champaign, and was accepted without funding. They were married when she received her B.A. Since his leaving the University of Illinois was not an option, she went to graduate school there. They had set up a timetable so the year he completed his PhD she would be ABD and together they could search for jobs. Prior to having children, there was an equal division of household labor. This division of labor was assumed to extend to children, from her perspective, but not from his. Owing to her illnesses and other "circumstances beyond their control," they fell off course. It soon became clear that she would not be ABD at the same time he would be finishing his PhD. When she received her M.A. it was decided that they would have children. They had children as he was writing his dissertation and again during his first year on the job. He accepted a job in California, and she assumed she would pursue her PhD part-time, as she was totally responsible for the childcare. When she got to California, she met people in the mathematics department and they arranged funding for her to go to school full-time. She is very clear about the fact that this was something her husband really supported. She vividly describes the problems and complications -- she was a full-time PhD student, a teaching assistant, and totally responsible for childcare. Her husband was constantly working and building his career. As she says, "the problem with my husband was that he is always at a critical point in his career." (6225) When she finished her PhD, he was denied tenure. For the most part they applied for jobs in the same geographic location. However, he was offered a tenured associate professorship at Michigan State University, while she was offered a two year postdoctoral instructorship at the University of Chicago. They decided to have a commuter marriage. She and the children would live in Chicago; he in East Lansing. This arrangement lasted two years and she was offered a tenure track assistant professorship at Michigan State University. She feels the two year commuter arrangement was healthy. He is now more responsible for and responsive to family concerns. Although she will always be the primary childcare person, she believes that things are better now and it is due in a large part to commuting for two years. Had this woman not gotten a job where her husband was raises interesting hypothetical issues, ones she did not want to explore. This respondent offers an interesting, yet perplexing quote. It is obvious her career is important to her. However, she is ambivalent about the importance of her being a mathematician.

> I mean I think I would if you asked me to define myself perhaps I would start out by saying my family is the most important thing to me. And I have a role as an individual which includes a lot of things and a lot of relationships to people. A role as a mother and a role as a spouse and a role as a daughter. And those are probably found not in this order at all. Mother, spouse, daughter are things that are extremely important to me. And just that I have certain values such as honesty and loyalty and this sort of thing. And I mean way down somewhere else unless we were in a situation where it was clear that you meant what you do for a living, way down would be mathematics....I mean mathematics is an important part of my life. It's not as important to me as my relationships with other people. My friendships are more important to me than mathematics. And not only my children are more important to me, but my close friendships are. And I think that for most men that is not true because I think that most men don't have close friendships (6259).

Our impressions from the female faculty interviews is that their husbands were supportive of them in general and particularly during times of ambiguity. Husbands do what they can so that the woman can pursue various activities, but home and childcare responsibilities basically belong to the realm of the wife.

> What was happening most of the time was that he was at my side as a cheerleader, which is important. I'm not trying to say that it isn't but then when it came down to changing diapers, well he changed enough diapers but doing the laundry for the children or taking care of the children, then he would have work to do (6244).

> Well he finally encouraged me to go and take a full time job because I was very miserable when I stayed home....He just shared in urging me to go out and get a job. He didn't share in anything else (6764-6765).

These women seem resigned to the status quo and the slow incremental change that occurs which they regard as better than nothing.

Summary for Chapter VI

This chapter has considered data obtained from the faculty respondents in our study. These data pertain to processes of becoming a mathematician, the work and meaning of mathematics, and the career and family contingencies in their lives. A number of general findings can be stated. We found that while the vast majority of the faculty were positively supported in their decision to become mathematicians, the females experienced a rather consistent reminder that, as one put it, "they have to live in society." This reminder took the form of messages that marriages and "suitable work" would be considered as practical alternatives to mathematics. Males did not experience these deflecting processes. Rather, they were allowed and encouraged to pursue professional goals. This freedom to become focused on a pursuit to their liking meant that variation in their educational trajectories to the PhD did not become problematic for them.

Nearly all faculty respondents conversed easily about the aesthetic and intuitive nature of mathematics. We hypothesize, however, that the focused backgrounds of the males allowed them to translate that aesthetic and intuition into a predominantly singular style of work expereince. They tend to work alone or, when collaborating, those relationships have very much of a work focus. Females, on the other hand, are less likely to prefer the singular style of work. Their collaborations tend to focus on the collective nature of the work as opposed to the work itself. The cleavage in work styles, we believe, is a logical extension of the sex differentiated nature of educational and family backgrounds.

That cleavage also appears in the data on role modeling and networking. Although the pervasive pattern is one of passivity in being role models for students, the female faculty tend more than male faculty to express the value of the personal aspects of role modeling. Males, on the other hand, tend to focus on work and individuals developing on their own. This focus on work also spills over into college networks with males tending to keep up with colleagues based more on professional ties and females basing ties more on personal friendships.

CHAPTER VII

CONCLUSIONS

In concluding this report, we wish to stress the long term and cumulative processes of sex differentiation. That is, not only does sex differentiation occur early in a person's life but the patterns of participation, vocabularies of motive, and meanings that are expressed through that differentiation build up and affect the person's conduct and options later in life. This is revealed in our major findings.

First, sex differences in schooling at the high school level and before were minimal, if nonexistent. Males and females were equally exposed to female math and science teachers, course taking, and advanced math track participation. Also, level of encouragement was essentially the same. The major difference in schooling was that a portion of females who were encouraged to continue in math also experienced discouragement. Our major finding here, therefore, is that while schooling was non-differentiated, mixed messages were more characteristic of female experiences than those of males.

Second, there was an over-riding similarity in career goals while in high school; males and females were equally oriented toward professional occupations with the exception of education. In that area, males more frequently focused specifically on university careers in mathematics while females focused on secondary school teaching in mathematics. This dissimilarity, especially for the graduate student sample, was also expressed through parental influence on career orientation.

Third, the major analytical theme of this study is that there is significant sex differentiation in the social worlds and orientations which contextualize male and female students. These worlds are composed of meanings, vocabularies of motive, and patterns of personal choice. The concepts we use to describe those differences are the focused worlds of males and the diffuse worlds of females. Nearly all our findings relate either directly or indirectly to the differentiation of these worlds. We suggest that the origins of focused worlds rest in part in the focused messages males receive from family and school; the diffuse worlds of females originate in part in the mixed messages they receive. We further suggest that these worlds are carried with males and females as orienting perspectives into their lives as young adults and that these perspectives influence how they participate in public spheres.

Fourth, focused and diffuse worlds are expressed through a variety of experiences, values, and decisions. Males' decisions to major in mathematics in college tend to be based on the positive value of mathematics; females' decisions tend to incorporate factors outside of the subject matter of math. Males tend to select a college for its academic excellence; females, in addition to that criterion, incorporate a number of "circumstances" into their decisions. Males define their major problem in terms of their ability to perform well at mathematics; females modify that assessment by also defining problems in terms of social relationships.

Fifth, findings noted in the previous paragraph enable us to better specify a theme concerning the sex differences in the relationship between math and other arenas of participation. The focused worlds of males are composed of primary meanings imputed to activities directly involving mathematics and secondary meanings of those not directly involving mathematics. The pursuit of mathematics, in other words, modifies other patterns of participation. The diffuse worlds of females are composed of primary meanings imputed to activities not directly involving mathematics. These meanings modify activities directly involving mathematics, which, as a consequence, become secondary. This difference is a sensitizing distinction, and does not apply equally to all individuals, but we suggest that it becomes sharper in form as individuals move from undergraduate to graduate education in mathematics.

Sixth, anticipated patterns of career and family participation were clearly sex differentiated for undergraduates. Males envision what we termed linear futures, in which work was their main involvement and family was a desired but side involvement. Females envision what we termed contingent futures, in which main involvements disappeared in ambivalence about how career and family would relate to one another. The significance of this finding is twofold: these futures exist in the present and thus become very much a part of focused and diffuse worlds, and the anticipations of these futures form the base of self-fulfilling prophecies, which contribute to their actualization. This reflexive process, of course, exists in a cultural context that permits it to operate and it reinforces the conditions of choice.

Seventh, male and female graduate students enter graduate school on unequal footing. The source of this inequity is traceable to the conditions that gave rise to focused and diffuse social worlds. Males have had long term intrinsic interest in mathematics and in aspiring to become mathematicians. Females tend to begin their graduate training with less specific career goals, and their motives for going to graduate school are not as focused as those of males. This differential base of entry becomes refied in meanings and activities during graduate school. Males work longer hours, define their major problems in terms of activities related directly to mathematics, interact with faculty on an individualistic and task-oriented basis, and see sponsorship in pragmatic terms. Females define their major problems as those embedded in the social arenas, identify with friends and family more than do males, prefer the organized classroom as a format for learning mathematics, and see sponsorship more in terms of nurturance. While clearly a higher proportion of female graduate students than female undergraduates are specifically careerist, a significant proportion also express ambivalence about family and career participation.

Eighth, we found no evidence of overt barriers to females who pursue mathematics through to the completion of the PhD, and thus we are reluctant to conclude that overt sex discrimination systematically exists in mathematics. We do maintain that these processes leading to sex differentiated contexts in which males and females attempt to become mathematicians tend to be advantageous for males. The nature of the barriers we can empirically document, however, were covert in nature. They were expressed through females' perceptions that they were not being taken as seriously and in their feeling of themselves as a numerical minority. Although more females than males reported that sex stereotyping was a problem, a majority of females stated it was not a problem. Both male and female respondents were hard put to come up with stories of active resistance to female students.

Ninth, the life histories of faculty tend to reflect the distinction between focused and diffuse social worlds, although a significant proportion of the female faculty display focused orientations. We conclude that one of the significant processes leading to the PhD is self-selection and that this process for females enables those with focused orientations to complete their education more readily than those with diffuse orientations. Regardless, female work styles (collectively-oriented) tend to conform to the diffuse mode and male work styles (singularity-oriented) tend to conform to the focused mode.

Tenth, findings from data on role modeling were rather a surprise to us. Males have fewer role models than females, and when they do name someone as role model, that person tends to be a professor. Females list family and friends as role models more frequently than do males. We believe these findings also reflect focused and diffuse social worlds. The surprise was in finding that undergraduate females do not model themselves after female faculty, and if anything, see those faculty in negative terms. The faculty, moreover, are not overwhelmingly attracted to the concept of role modeling. They are at best passive participants in the process and, while there are those who express a willingness to serve as role models, the modal response was to emphasize the burdensome and dysfunctional qualities. On this basis, we cannot support the contention that role modeling is a process which contains promise to reduce sex inequities in mathematics.

Implications for Policy

We have argued that focused vs diffuse orientations, which are long term and cumulative contextual properties, account for much of the sex differentiated nature of experiences related to mathematics. Those orientations, however, are created from the intersection not only of schools and universities, but also of families, friends, personal values, and personal decision making. How can the responsibility for the creation of those orientations be assessed in a way that would lead to an appropriate policy formulation? Frankly, we are troubled by that question, and we take the position that the answers depend very much on one's perspectives or assumptions.

If one assumes, for example, that the only function of a university department is to perpetuate a manpower pool, then it is justified in putting its energies primarily into those students who most likely will complete the requirements for the PhD on time and fill vacant slots in the labor force. Certainly attention must be given to the problem of the turnover of personnel. If, however, one assumes that an additional mandate of departments is to identify and nurture the intellectual growth of talented students, then perhaps departments must broaden their efforts. Such broadening could take the form of a more compassionate view of students; they represent not only a potential manpower pool but human beings with biographies that may militate against or facilitate the expression of talent. We suspect that departments would respond to us by asserting that they do both. And indeed we think most departemnts sincerely believe they do. Our point, however, is that the identification and promotion of talent is an exceedingly complex process that must involve looking beyond performance per se. Departments can ill-afford to view their students merely as products that only need to be packaged and marketed. The social orders that students bring with them show otherwise. The issue of how work and family participation is integrated, for example, is far from resolved. It is true that there is a public dialogue about how men and women will coordinate the sometimes conflicting demands of work and family, but how those demands are to be resolved is not yet part of our culture. Females currently envision themselves as sacrificing their early careers, and they express a great deal of ambivalence about the trade-offs they face. Males do not envision such trade-offs, but we believe that they cannot exempt themselves either from the dialogue or the ambivalence. Part of the current divorce rate of middle aged couples, for instance, is due to males' lack of partipation in discussions of these issues. We therefore emphasize that changes in the social order in which males and females participate must become part of the agenda in university departments.

The complexities underlying that emphasis should, at this point of our report, be manifest. Those complexities inherently involve the interaction of an individual and society, and raise as a serious issue the kind of person someone is becoming while living his or her life. Surrounding this issue of "becoming" is the interaction of multiple decision-makers, including the individual. In this sense, one of the implications of our research is that individual decision making and personal weighing of the value of multiple choices is part of the process of sex differentiation in mathematics. Males and females, in other words, are not only differentiated by society, but they also differentiate themselves. We insist we are not blaming the "victim," but at the same time we cannot blame "society." Causation does not rest in those polarities. Rather, we recognize that the processes that create and perpetuate sex differentiation involve the interaction of systems of freedom and constraint that are not only derived from the actions of others but from the actions people impose on themselves. Through the process of making situational adjustments in their lives, people commit themselves to lines of action with future consequences they may or may not anticipate. Thus, individuals, both male and female, must accept a measure of responsibility for the choices they make when presented with an array of options.

While we maintain that an emphasis on individual decision making is a proper one, we also must emphasize that the distribution of all possible choices is not entirely controlled by the individual. The social order exists prior to the individual, and it presents them with sex differentiated realities. It is exactly in this sphere where families, schools, and friends combine to reify the norms and contexts of becoming. In other words, the rationale and substance of choice often are imposed on the person in a way that sets the probabilities that certain choices will be made. It is precisely this process that departments should be aware of simply because it often masks talent.

These sets of issues lead us to contend that the complexities of sex differentiation are much more profound than we had anticipated or read in any program statement or research report. Indeed, if our data could support the contention that early influences in math were the critical factor for the groups we studied, we could make recommendations concerning elementary education. We also could make recommendations if our data pointed to inequities in secondary education. But our data reveal that early schooling influences do not appear as significant factors for the individuals we studied, so those kinds of policy recommendations are not possible. On the other hand, we remind the reader that our study considers only the "successes" -- those who survived all the documented or potential influences that combine to produce enormous sex differences in mathematics for the general population of males and females. Two conclusions thus follow. First, policy recommendations based on other studies should be implemented to increase the number of females who survive the elementary and secondary school experiences as "successes" still interested in mathematics. Second, we must not overlook the individualism and determination of the females we did study as important components of their success. No matter how diffuse that group may be in comparison to males, when compared to all females it appears very focused.

Accordingly, one of the possibilities we must seriously consider is that women who persist in mathematics are in some respects self selected, are those who can deflect experiences which militate against persistence, and who have a personal tolerance for isolation. This consideration suggests that women who do persist adopt the "male model" to some degree. We reject the form of that expression as sexist, but at the same time wish to inquire into fundamental processes that are implied by it. We can make that inquiry by asking about the functions of being focused, as opposed to being diffuse. We find that when women are focused and exposed to interpersonal and professional opportunities, their career performance exceeds that of diffuse males. What this notion implies is that the question of skewed sex distributions in mathematics is not directly an issue of sex. Rather, it is an issue of the structure of the self in relation to the distribution of influence and patterns of participation in public and private arenas. Therefore, sex differentiation in mathematics as sex differentiation exists only insofar as these influences and patterns of participation are more characteristic of females than males. Of course, the fact of the matter is that most males are not likely to be so exposed. However, the implication of this notion is that if males were exposed to patterns that typify females' lives, they would experience many (but obviously not all) of the same kinds of problems that females experience. This contention, which is offered here only as an implication of our data, is supported by a preliminary analysis of our current NIE funded study (NIE-G-81-0029) of processes of attrition of males and females out of mathematics. That analysis shows that males who drop out of math at the same points that females drop out tend to have similarly diffuse orientations and backgrounds. We therefore wish to underscore the point that sex differentiation is only a rough indicator of a more fundamental differentiation (ie., focused vs diffuse) in mathematics.

Why does this differentiation show up in mathematics? We believe the answer must consider seriously the nature of mathematics itself. Mathematics, perhaps more than any other academic discipline, is cumulative in nature. The successful understanding of advanced mathematics depends upon the successful understanding of less advanced mathematics. Mathematical knowledge and understanding is built up, not merely acquired. This means that those who do not have a firm grasp of early mathematical concepts will have an exceedingly difficult if not impossible task of catching up. It is not just the building up of mathematical knowledge that we wish to emphasize here, however, but that focused persons are more likely to have that basic understanding of concepts and theory that will allow them to persist. With this in mind, we can propose that focused orientations become very important in the pursuit of mathematics and the forging of careers in the field. These orientations, in fact, might be thought of as functional requisites for mathematical performance. To the extent that women do not acquire those orientations, they, as a consequence, are disadvantaged. Conversely, to the extent that males do acquire them, they perpetuate the skewed sex distributions.

Because these processes are so broad based and represent the interpenetration of many sectors of society, we resist the temptation to offer fast and easy recommendations. Policy which is disrespectful of empirical and conceptual findings does not constitute a public service. However, we can pose the following issues and recommendations. First, we should reconsider the question of whether the goal of producing more women with Ph.D.'s in mathematics is worthwhile. Persons with doctorates in mathematics tend to be highly specialized and thus qualified for only a narrow sector of the labor market. To the extent that job market demands are restricted, an overproduction in the supply of job applicants, whether male or female, qualified or unqualified, is a less than laudable objective. Second, this issue of supply raises the question of how much mathematics is required by females to enable them, on the basis of mathematical skills, to compete equitably with males in the job market. This question pertains to the amount and nature of mathematics demanded by the job itself. We know that roughly two-thirds of the labor market requires some mathematics, and to the extent that females do not possess mathematical skills, they cannot successfully compete for those jobs. A college major or minor in mathematics, combined with a major or minor in another field, might well give females the best combination of skills either for immediate entry into the labor market or for advanced graduate training in fields other than mathematics. From this standpoint, departments might well begin to find solutions to sex inequity by offering minors or other structural programs in mathematics that are specifically designed to meet the various labor market demands of, say, social science, pre-law, pre-med, engineering, or humanities majors. Third, insofar as sex differentiation in mathematics is so broad based, the means of encouraging young males and females must be correspondingly broad. Clearly this is the most difficult policy question of all, because it involves the private spheres of family and friendship participation. However, after-school clubs or activities involving mathematics might be designed to help females achieve more focused orientations. Diffuse females must somehow acquire a capacity to deflect militating influences and they must learn to "see" mathematics in their daily lives as males tend to do. Educational institutions, teachers, and parents can encourage this by making an effort to channel leisure time and to encourage females to play at mathematics as men and boys do. Any program such as this must allow for individual differences yet be sex blind in its structure and functioning. This kind of activity would not be designed to produce more female mathematicians, but to help provide for them a set of values, self perceptions, and facts about the world that they can use in making their own decisions later in life. Fourth, in light of contemporary times, graduate departments must diversify yet focus even harder on instilling excellence in their graduate students. This notion implies that equity cannot be achieved solely through programs such as affirmative action (although such programs certainly function well to sensitize people to issues of inequity) or forms of "reverse discrimination." Rather equity must come from responsible responses to conditions of pluralism. The organization of departments must be capable of instilling excellence not only in students oriented toward research in pure mathematics but in the applied areas as well as secondary education. This horizontal diversification, which would reflect various career and personal goals of students, must be accompanied by vertical integration. Such integration would tend to eliminate the prestige hierarchy in mathematics which has a tendency to discredit areas not directly relating to pure mathematics. The uniform emphasis on excellence could be reflected in faculty positions that pertain directly to alternative careers in mathematics and in which incumbants of those positions are rewarded not solely on the basis of their mathematical discoveries but on the basis of their performance in alternative career education and placement. The concern for both diversification and excellence as two fundamentally inseperable dimensions of graduate departments could have the consequence of identifying and nuturing talent in students whether they conform to the focused or diffuse models previously discussed.

This concern stems not only from the findings of our research but from our personal values. Those values hold that, above all, educational institutions are in the business of producing excellence. To the extent that systematic patterns of differentiation, such as those based on sex, inhibit the identification and development of talent, however, those institutions must be held accountable for failing their mandate.

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APPENDIX A

INTERVIEW GUIDE FOR UNDERGRADUATE STUDENTS

INTERVIEW GUIDE FOR UNDERGRADUATE STUDENTS

WHAT I WOULD LIKE TO KNOW ABOUT IN GENERAL IS YOUR LIFE HISTORY-- AND MORE SPECIFICALLY ABOUT YOUR EDUCATIONAL HISTORY. IN PARTICULAR, I AM INTERESTED IN YOUR RELATIONSHIPS WITH OTHER PEOPLE--THOSE WHO HAVE INFLUENCED YOU IN ONE WAY OR ANOTHER, FOR EXAMPLE.

SO, PERHAPS WE COULD START WITH YOUR HIGH SCHOOL EXPERIENCES.

A. HIGH SCHOOL EXPERIENCES

1. From among academic subjects, sports, social life, extra-curricular activities and the like, what were you the most interested in and involved in when in high school?

2. What were you the most interested in academically? What were you the least interested in?

3. How did you get into the math curriculum? Was there a math major in your high school?

4. Exactly what math courses did you take?

5. Was there anyone in particular who encouraged or advised you to go into math? (Always probe specifically for family members, teachers, guidance counselors, etc.)

   Did anyone advise you not to go into math? Who? What did they say?

6. Did you have any female math or science teachers in high school? How did they act towards you? Was there any sense in which they were different from your male math teachers? Did they take special interest in you?

7. What were your career plans when you were in high school? Who was influential in helping you form those plans?

8. What did your mother and father want you to be? (If respondent says, "Anything I wanted to be," try to get specifics. You might play dumb by saying, "Do you mean that they didn't care at all what you wanted to be?"

BEFORE WE MOVE ON AND TALK ABOUT YOUR COLLEGE EXPERIENCES, CAN YOU TELL ME IF YOU HAD ANY SPECIAL MATH COURSES OR EXPERIENCES BEFORE HIGH SCHOOL?

B. COLLEGE EXPERIENCES

9. What does a typical day look like for you in college? Describe it for me. (Probe for amount of time studying (hours/day) in general and in math; dating; messing around; extra-curricular activities).

10. Do certain people in your classes study together? Who are they? Do you participate?

11. What proportion of your friends are math majors? About how many? How about science majors? If no math or science friends, then who are your friends?

12. Why did you decide to go to Circle, NU, Chicago, DePaul?

13. How did you come to decide to major in mathematics? When did you make that decision?

14. Have you had any previous majors besides math?

15. Since declaring your major, have you considered changing from math? To what? Why? Have you considered other math-related majors, such as computer science?

16. Besides mathematics, what subjects are you the most interested in? Which ones are you the least interested in?

17. Do you personally find any kind of resistance to women in math from professors? IF NOT, any bad vibes or any sort? How about from family? Friends? Other students? (In each case, probe for the nature of the resistance or bad vibes).

18. In your years as a math major, have you known anyone who has switched out of math? Who? Describe the circumstances for me.

19. No matter how minor they might be, can you tell me in what respects females might not be taken as seriously as males in math?

20. In what respects is it harder for females in math to make it?

21. Do you see the mathematics department here making any special efforts on behalf of female math students?

22. Have any of your college math professors been women? How did they act toward you? Was there any sense at all in which they were different from your male professors? Did they take any special interest in you?

23. In what respects are the experiences of a female math student different from those of a male math student?

24. It is often said that being a female math or science major and being feminine do not go together too well--that somehow it is like mixing oil and water. Have you ever had any personal feelings along these lines? Has anyone ever been surprised when learning that you are a math major?

25. What is it about math that it is often thought of as a masculine field?

26. If there were one or two things above all else that you would pick out as the most difficult for females in math to deal with or overcome, what would they be? Why is that?

NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT SPECIFIC KINDS OF PEOPLE YOU ENCOUNTER IN COLLEGE.

C. ROLE MODELS

27. First, though, in retrospect, have you ever found that you had been influenced by someone even though you weren't aware of it at the time? Describe that for me.

(NOTE: Ask questions 28-31 sequentially)

28. What are the qualities in a person you most admire? How about in a professor?

29. Are there people you know who have those qualities? What is your relationship with those people?

30. Is there one person you know of who best exemplifies those qualities? Two people?

31. Would you call that person a role model for yourself? In what respects is that person a model for you?

32. When you think of the notion of "role model", what comes to mind? What does the term mean to you?

33. If you stayed on here, is there anyone you would prefer to work with? Who? What kind of relationship do you have with that person? Would you call that person a role model?

34. Whom would you go to for recommendations? How well do you know each other? What is it about that person that makes you select him/her? If faculty, did you get A's from them?

35. Do you think it is important for professors to take a special interest in students? How so?

36. To what degree have any of your professors taken a special interest in you? Describe it for me.

37. Do you know of any famous mathematicians? Read about them? What do you think about these people?

38. When you just sort of relax and are maybe not too serious, is there anyone you think you would really like to be like?

39. How about just doing math. Is there someone who has influenced your thinking about, say, the "best way" to do math or be a mathematician?

40. Is there a female math or science professor--or TA--whose life style you admire? Do they in any sense provide you with an example of the kinds of options that might be open to you?

41. Finally, before moving on to the last section, have you ever had any discussion with any of your female math professors about any special problems female math students have or might have? Describe.

FINALLY, I WOULD LIKE TO TALK ABOUT YOUR ASPIRATIONS AND CAREER PLANS.

D. ASPIRATIONS

42. What do you see yourself doing when you finish your degree? How about afterwards, say, in 10 years?

43. What are the career options in math or for someone with training in math? Which fields do you feel you are most suited for? Which ones do you feel you would have the most difficulty getting in?

44. Is there any particular job you are especially interested in obtaining? How did you come to select that job?

45. What do you see as the greatest difficulties in getting where you want to go professionally? How do you plan on overcoming those difficulties?

46. Have you considered going to graduate school? In math or some other field? If not, why not?

47. To what extent is marriage a part of your plans for the future? What about children? What about the task of coordinating home and work obligations and conflicts?

48. What options do you see open to you in terms of home and work? What compromises are you willing to make? Not willing to make?

49. Is there anyone you are associated with now that you think you might like to be like in the future?

50. What does your family think about your career plans and aspirations? Do they think your plans are realistic? Are they supportive? Or not?

51. Who has been the most influential in your forming your career plans?

JUST ONE LAST QUESTION.

52. Why is it that there are so few females in mathematics? And, what should be done to get more females in the field? (Always probe this set of questions. Get an account of the issue. Try to make them explain why the sex ratio is skewed and push them for how they think it should be evened out).

Does the notion of "intuition" in math mean anything to you? If yes, what?

If NO, say: "I've heard it used to refer to the mental process where if you were asked to prove something or another, you could look at it in your mind and say, "that's true" or "that's false". Are you familiar with that phenomenon? Is there a word you have heard used to describe it?

How important is it to have such intuition to be really good at math?

Have you ever discussed it with an advisor or professor, or has the general topic of mathematical creativity ever come up in your conversations with faculty, TA's, etc?

Also, be sure to ask if they think that males and females have different types, amounts, etc. of math intuition. For example, you might ask, "In what respects can it be said that males and females have different kinds of math intuition?"

You also can come right out and ask, "Do you think that males and females are different with respect to math intuition?" Or, "It is often said that males have better math intuition than females. What do you think of this idea?"

APPENDIX B

INTERVIEW GUIDE FOR GRADUATE STUDENTS

INTERVIEW GUIDE FOR GRADUATE STUDENTS

A. RECONSTRUCTION OF PRE-COLLEGE EXPERIENCES

1. Can you point to a time when you first became really interested in mathematics? When? Was there someone who really made mathematics interesting for you?

2. Characterize your high school life for me. For instance, what were you mainly interested in?

3. Were you on an advanced track in math during high school? How many years of math credit did you get while in high school?

4. Was there anyone in particular who encouraged you or advised you to go into mathematics? (Family members, teachers, guidance counselors?) Did anyone attempt to discourage you?

5. Did you have any female math or science teachers in high school? What were they like? How were they different than your male teachers? Did they take any special interest in you?

6. What were your career plans when in high school?

7. When in high school, what was your understanding of what your parents wanted you to be?

B. RECONSTRUCTION OF COLLEGE EXPERIENCES

NOTE: Questions 8-11 are designed to obtain a life history of the decision process to major in mathematics.

8. Why did you decide to go to (Wherever they went) as an undergraduate?

9. How did you come to decide to major in mathematics? When did you make that decision?

10. Have you had any previous majors besides math?

11. After declaring your major in math, did you ever consider changing out of math? To what major? Why? Have you considered math-related majors such as computer science?

12. Besides math, what subjects were you the most interested in in college? The least interested in?

NOTE: Questions 13-15 are designed to describe college life style.

13. Characterize your experiences as an undergraduate for me. Describe it for me (hours/day studying math--other subjects; dating; messing around; extra-curricular activities).

14. Did certain people study together? Were these formal study groups? Did you participate? Who were they (sex)?

15. What proportion of your friends as an undergraduate were math majors? About how many? How about science majors? If there were no math or science friends, ask who were his/her friends.

16. Exactly how many math courses did you take as an undergraduate beyond what was required for a math major? Which areas of math did you like best? Which ones did you do best in?

17. Did you have any female math professors as an undergraduate? Was there any sense in which they were different than your male professors? How did they act toward you? Did they take any special interest in you?

18. No matter how minor they might be, can you tell me in what respects were the experiences of females as undergraduate math majors different from those of male undergraduate math majors?

19. When you were an undergraduate, what did you think of the male math majors? (If you don't get a good answer, probe by saying, "Well, there had to be so many of them--didn't they sort of dominate the situation?")

20. When you were an undergraduate, what did your academic advisers tell you when you would talk about your future with them? Were they encouraging? Discouraging? In what respects?

21. What were your career plans as an undergraduate? When did you decide to go to graduate school?

C. GRADUATE SCHOOL EXPERIENCES

NOTE: Questions 22-24 are designed to obtain a life history account of how he/she came to go to graduate school in math.

22. Why did you decide to get a graduate degree in math? What else did you consider? Did you consider any other graduate majors besides math?

23. Why did you decide to go to graduate school at Circle, NU, Chicago?

24. Was there someone in particular here you wanted to study with? How about since coming here?

25. What does a typical day look like for you? (Key on sequence of activities).

26. How many hours/day do you spend on math only? (Get a time budget for the two previous days).

27. How often do you talk about math with other graduate students? Where do youdo this? (eg. home, office, etc.).

28. Is there someone in particular with whom you regularly talk about math? Who? Their sex. Advanced or not? Same math specialty?

29. How often do you talk about math with the faculty? Someone in particular?

30. What do people do when they "study math"? How much time is spent in class vs independent work? Do you use computers? (NOTE: Key on the idea of the extent to which math work is collective or isolated work).

31. What are the qualities of a good mathematician?

32. Does the notion of "math intuition" mean anything to you? If yes, what? (IF THEY SAY NO, SAY, "I've heard it used to refer to the mental process where if you were asked to prove something or another, you could look at it in your mind and say 'that's true' or 'that's false'. Are you familiar with that phenomenon? Is there a word you have heard used to describe it?")

How important is it to have such intuition to be really good at math?

Do you think that males have a different type of math intuition than females?

33. Is there a student in the department who is generally regarded as the "best student"? What is it about that person that makes him/her regarded as the best? What does being "superior in math" mean? What are the differences between those who are superior and those who are not?

34. Is there a faculty member in this department who is regarded by the students as the "best mathematician"? Best teacher? Best researcher? Best person? What is it about these people that makes them so regarded?

35. What do you see as the basic differences between male and female graduate students? Are females as good in math as males? If not, why?

36. Have you ever had the opportunity to work with a female math professor? Have you done so? Are there any career implications of working with a female professor as opposed to a male professor?

37. If there were one or two things above all else that you would pick out as the most difficult for females in math to deal with or overcome, what would they be? Why is that?

38. What is it about math that it often is thought of as a masculine field?

39. It often is said that being a female math or science major and being feminine do not go together too well--that somehow it is like mixing oil and water. Have you ever thought about that or had any personal feelings along those lines? Has anyone ever been surprised to learn that you are a math major?

D. ROLE MODELS

NOTE: Ask questions 40-44 sequentially.

40. What are the qualities you most admire in a person? How about in a professor?

41. Are there people you know who have those qualities? What is your relationship with those people?

42. Is there one person you know who best exemplifies those qualities? Two people?

43. Would you call that person a role model? In what respects is that person a role model for you?

44. When you think of the notion of "role model", what comes to mind? What does the term mean to you?

45. If you stayed here after your Ph.D., is there someone you would prefer to work with? Who? What is your relationship with that person? Would you call that person a role model?

46. To whom would you go for a letter of recommendation? How well do you know that person? What is it about that person that you would select him/her?

47. Do you think it is important for professors to take a special interest in graduate students?

48. To what degree have professors taken a special interest in you? Describe fully. Any female professors?

49. Do you ever go to professional meetings? How often? Ever give a paper? With a professor?

50. To what extent have you gotten to know math professors from other departments? How well? How did you come to know them?

51. Is there someone who has influenced you in terms of say, the "best" way to do mathematics?

52. Do you ever talk with your professors about career management? With other graduate students?

53. Have you ever had any discussions with any of your female math professors about any special problems female math students have or might have? Describe fully. Discussions with male professors?

54. What kind of sacrifices are necessary to be a truly successful mathematician?

55. There is the phenomena of sponsorship of graduate students by faculty. What does that term mean to you? Ideally, how does the process of sponsorship work? How necessary is it for graduate students to be sponsored in terms of their future professional career? To what extent have you been sponsored? How close to the ideal was it?

56. Do you see any differences in the ways female and male graduate students are sponsored?

57. Do you think that male faculty can be effective role models for females? IF YES, in what respects? IF NO, why not?

E. ASPIRATIONS

58. What do you see yourself doing after you finish your Ph.D.? How about afterwards, say in ten years?

59. What are the career options in math or for someone with graduate training in math? Which fields do you see yourself most suited for? Which ones do you think you would have difficulty getting in?

60. Is there any particular job you are especially interested in getting?

61. What do you see as the greatest difficulties in getting where you want to go professionally? How do you plan on overcoming those difficulties?

62. IF MARRIED: Tell me about how you and your husband work out the dual career situation. Do you talk about it much? Whose career comes first? How do you plan on dealing with the issue of children?

63. IF NOT MARRIED: To what extent is marriage a part of your plans for the future? What about children? What are your thoughts about potential problems in coordinating work and home obligations?

64. What compromises are you willint to make with regard to home/work obligations? Not willing to make?

65. What does your family think about your career plans and aspirations?

66. Who has been most influential in forming your career plans?

JUST TWO MORE QUESTIONS

67. What are the differences between American and foreign students in math? Ability? Hard working? Career possibilities? Family support systems? Are the two competitive with one another? Favoritism?

68. Why is it that there are so few females in mathematics? (PROBE this question to get them to think about it. Get some kind of account). Also, what should be done to get more females in math? Or, is it necessary in your opinion to get more females in math?

APPENDIX C

INTERVIEW GUIDE FOR FACULTY

INTERVIEW GUIDE FOR FACULTY

A. LIFE HISTORY OF TWO-CAREER MARRIAGE

ASK: Are you married?

IF YES OR NO, SAY: One of the things we've been concerned with in the interviews with undergraduate and graduate students in math is how they intend to manage work/family situations, their perception of issues that might arise, etc. So, I wonder if we might talk just for a few minutes about that before we get started.

IF MARRIED, ASK:

(a) How old were you when you got married?

(b) Do you have children? How many?

(c) Where were you in your education when they were born?

(d) CAN YOU START AT THE BEGINNING AND TELL ME ABOUT THE DECISIONS YOU AND YOUR HUSBAND MADE IN THE COURSE OF GETTING TO WHERE YOU ARE TODAY? I'M INTERESTED IN THE STORY OF THE HISTORY OF YOUR WORK/FAMILY LIFE. (Probe ideas: whose career came first, who gave up what, who took care of the kids, how was time allocated, what was the criteria used for making career decisions).

(e) If you had to do it all over again, what would you do differently?

IF RESPONDENT IS NOT MARRIED, SAY:

(a) To what extent has your career been part of your reasons not to get married?

(b) Can you tell me any examples of how you chose not to get married?

B. HIGH SCHOOL AND UNDERGRADUATE YEARS

SAY: NOW, I WANT TO SHIFT TOPICS A BIT AND ASK YOU ABOUT YOUR EDUCATIONAL HISTORY.

1. How far back do you recall having had an interest and talent in math?

2. What sticks out in your mind about your high school years? For example, how would you characterize yourself as a high school student?

3. Tell me about your experiences with mathematics during high school. (RE: likes/dislikes, difficult or not, etc.)

4. Was anyone expecially influential during high school as far as your interest in math was concerned? IF NO, SAY: "teachers? parents?" "There was no one who encouraged or supported your interest in math?" IF YES, SAY: "Tell me about that person."

5. What did you think you wanted to do career-wise during your high school years? Who was influential as far as that went?

6. When you were in high school, did you ever talk about career plans with your parents? What did they tell you? What advice? What did you think they wanted you to be?

7. What was your undergraduate college major? How did you come to major in that?

8. Could you think back and tell me what your undergraduate years were like? What were you interested in? How did you spend your time?

9. Thinking about your college years, does anyone in particular stick out as having been especially influential or helpful to you academically or intellectually? IF NO, SAY: "No one? Everyone was the same?" IF YES, SAY: "Tell me about that person."

10. Did you have any female math or science teachers in college? Were they in any respects different from the male math or science professors? Did they show any special attention to you--sort of take you under their wing?

11. What was the general consensus about undergraduate females in math when you were an undergraduate?

12. What were your career plans while you were in college? What kinds of options did you think about? ASK: What were you absolutely sure you didn't want to do?

C. GRADUATE SCHOOL YEARS

SAY: OK, NOW LET'S MOVE ON TO YOUR YEARS IN GRADUATE SCHOOL.

13. How did you come to decide to go to graduate school in mathematics? What else did you consider doing?

14. Why did you decide to go to graduate school at ______? (eg., $, departmental reputation, convenience, famous person, etc.)

15. What did your family think of your going to graduate school in math? Tell me about that.

16. Tell me what your graduate school years were like.
    - What did a typical day look like?
    - What was the biggest problem for you there?
    - Were there study groups among the grad students?
    - Were you involved in those groups? (# women?)
    - What was the level of competition among the grad students?
    - Was there someone who was regarded as the "best student?"
    - Tell me about that student. (yr, behavior, etc.)
    - What kind of financial aid did you have?

17. During graduate school, was there anyone in particular who was especially influential or helpful for you? IF NO, SAY: "Not your advisor or anyone?" IF YES, SAY: "Tell me about that person."

18. Was there anyone else?

19. Did anyone express any specific interest in your future? Who? Tell me about that person? How did he/she express that interest?

20. Were there any negative role models--people that you knew that you didn't want to become like? Tell me about them.

21. When you were finishing the end of your graduate training, what was the job market like?

22. What kind of career-management advice did you get from your professors? How much help were they in getting you a job? Anyone in particular?

23. The terms "mentorship" and "sponsorship" sometimes are used to describe student/faculty relationships. Do either of these terms apply to any of the relationships you had with any of your professors? Tell me about those relationships.

24. About how many female graduate students were there when you were in graduate school? Roughly what was the sex ratio?

25. As a group, what were the differences between male and female graduate students in math?
    - Females more anxious?
    - Females work harder?
    - Females married or not?
    - Did males and females hang around together?
    - Were females taken as seriously as males?

26. How did the females collectively regard the males in the department? What did they think about them? (Probe hard).

27. Have you kept up on what happened to the people you went to graduate school with? Generally, how have they done? What about the females? (What do you attribute this to?)

D. EXPERIENCES AS FACULTY MEMBER

SAY: OK, NOW I WANT TO SWITCH TOPICS A BIT ONCE AGAIN AND ASK ABOUT YOUR EXPERIENCES AS A FACULTY MEMBER.

28. Tell me what it was like just getting started as a math professor? What were your highest and lowest priorities, for example? What were you most anxious about?

29. Was there anyone who was especially helpful during your first years?

30. To what extent do faculty members see one another during non-work occasions? Is there anyone in particular you are close to on the faculty? Tell me about it.

31. How would you characterize the faculty in terms of how they relate to one another as a group?

32. What is it like being a female in a predominantly male faculty?
    - -What are the liabilities and assets?
    - -What can't you do compared to a situation where there were a higher proportion of females?
    - -Does the sex ratio of the faculty affect decision making?

33. How many women have there been on the faculty here in the last ten years? Has there been any changes? What difference does it make?

34. Would you want to see a higher proportion of females on the faculty in your department? Why or why not?

35. Has the issue of women and math ever come up in faculty meetings? Informally among the faculty? Is there an official departmental policy regarding women and math? IF NOT, ASK: "Do you think one is needed?" Why or why not?

36. Has there been any discussion regarding the active recruitment of female faculty? Tell me about that.

37. What do you think about affirmative action?
    - -as a program
    - -as a policy
    - -Is it needed? Why or why not?

38. What is your teaching load? How many dissertation do you usually chair or work on? How many students do you actively work with?

39. What does "working with a student" look like in math? What do you do?

40. Compare for me your relationships with students when you first came and were starting your career and now.
    - amount of contact
    - frequency
    - have students changed?

41. How often do you talk to students about non-academic matters? What do you talk about? Are these students typically male or female?

42. How much do you get to know about students' personal lives?

43. How aware are you of the possibility of your being a role model for one or more students? How does this awareness affect the ways in which you treat them?

44. How has that awareness changed during the course of your academic career?

45. What does it mean to be a role model for a student?

46. Describe for me a role modeling relationship you have with a student. What does that relationship look like?

47. Are there difficulties in being a role model? What about your willingness to be one?

48. Can males be role models for female students? Can they be as effective in that capacity as female faculty? Why or why not?

49. Can female faculty be effective role models for male students? Why or why not?

50. As a faculty member, do you find that there are any differences in working with male versus female students?

51. The faculty here obviously are predominantly male. What do you see as the significance of that fact for the experiences of students? Does that fact make a difference for males versus females?

52. What are the relative odds of males versus females completing the graduate program here? Why is that? Or, tell me about that.

53. How do you personally explain the fact that females drop out of graduate programs in mathematics more frequently than males?

54. In what respects is it harder for females in mathematics than males?

55. What would you do if a competent female graduate student came to you and said that she was thinking about dropping out of graduate school because she found it too difficult to be a good mathematician and a good wife and mother at the same time? (Cont. on next page.)

55. (cont.) Has this ever happened to you? What did you do?
 -Would you be surprised?

56. This question is hard to ask, but if we want to find out about differences in male and female experiences, we have to ask it. The research in the social sciences indicates that in every male/female relationship there are patterns of behavior and expectations that function to maintain gender identities and gender-based roles. This can range from patterns relating to how males and females talk to one another to the extent to which they can be really close friends to issues of sexuality and sexual relationships. What we are especially interested in is how these are manifested in the relationships between male faculty and female graduate students. No matter how trivial you think it might be, I wonder if you could tell me about whether you have seen this in your years in mathematics.

57. SAY: OK, NOW I WANT TO SWITCH TOPICS A BIT ONCE AGAIN. What is meant by the notion of "Intuition" in mathematics? How important is it for doing mathematics?

58. Are students in math evaluated in terms of the degree to which they have math intuition or math creativity?
 -how do you recognize it in a student's work?
 -how about undergraduates versus graduate students?

59. Based on some of the interviews with undergraduates, it seems like the females get evaluated a bit differently than the males with respect to math intuition. What do you think is going on here?

SAY: JUST A FEW MORE QUESTIONS AND WE WILL BE FINISHED.

60. I've heard it said that mathematics is a very singular kind of work--that collective work is difficult and that specialization in math makes it hard for collaborative work. Can you tell me about that?

61. What do you see as the most essential qualities necessary to be a really good mathematician? (For each quality, ask why that is necessary).

62. How about being really productive?

63. What advice do you give females in mathematics about family/career decisions and management?

APPENDIX D

SUPPLEMENTARY TABLES FOR UNDERGRADUATE STUDENTS

Table D-1

Occupational Background of Undergraduate Students' Parents

	Father's Occupation		Mother's Occupation	
	Males	Females	Males	Females
	(N = 46)	(N = 42)	(N = 42)	(N = 48)
Physician	7	10	0	4
Businessman	28	12	2	2
Engineer	9	14	0	0
Clergy	2	0	0	0
College Professor	9	7	2	2
Blue Collar	25	43	33*	27*
High School Teacher	2	0	10	8
Other Professional	7	0	0	6
Farmer	0	2	0	0
Lower White Collar	11	12	4	2
Housewife	0	0	39	45
Part-time Work	0	0	10	4
	100	100	100	100

* 96% clerical/saleswork

Table D-2

Eduactional Background of Undergraduate Students' Parents

	Father's Education		Mother's Education	
	Males (N = 47)	Females (N = 49)	Males (N = 44)	Females (N = 40)
Less Than High School	11	6	2	10
High School	34	33	39	33
Some College	11	8	23	28
Bachelor's Degree	12	21	23	11
Some Graduate Work	12	0	11	2
Master's Degree	4	8	2	8
Professional Degree	16	24	0	8
	100	100	100	100

Table D-3

Distribution of Academic Honors for Undergraduate Students

	Males (N = 45)	Females (N = 49)
None	36	20
One	31	31
Two	20	27
Three	9	12
Four	2	0
Five or More	2	10
	100	100

Table D-4

Students' Assessments of Their Earliest Interest in Math

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 47)	(N = 37)	(N = 25)	(N = 17)
Pre-elementary	6	3	8	6
Elementary School	36	73	48	41
Junior High School	30	14	12	12
High School	17	5	32	18
College	2	0	0	18
No Early Interest	9	5	0	6
	100	100	100	100

Table D-5

Academic Areas Liked and Disliked by Undergraduates When in High School

	Most Liked		Least Liked	
	Males	Females	Males	Females
	(N = 50)	(N = 59)	(N = 37)	(N = 44)
Math/Science	84	68	11	25
Liberal Arts	16	29	83	75
Bookkeeping/ Shop	0	3	6	0
	100	100	100	100

Table D-6

Distribution of Undergraduate Students on Advanced Math Track During High School

	Males (N = 43)	Females (N = 39)
On Advanced Track	70	79
Not on Advanced Track	21	15
No Tracking in High School	9	6
	100	100

Table D-7

Students Who Had Female Math/Science Teacher in High School

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 47)	(N = 44)	(N = 25)	(N = 15)
Yes	66	79	72	73
No	34	21	28	27
	100	100	100	100

Students' Perception of Any Differences Between Male and Female High School Math/Science Teachers

	Undergraduate Student		Graduate Student	
	Males	Females	Males	Females
	(N = 27)	(N = 32)	(N = 15)	(N = 7)
Yes	52	47	60	43
No	48	53	40	57
	100	100	100	100

Table D-8

Undergraduate Responses to: "Are Mathematics and Femininity Compatible?"

	Males (N = 43)	Females (N = 41)
Yes	77	88
No	23	12
	100	100

Table D-9

Undergraduates' Familiarity About Famous Mathematicians

	Males (N = 46)	Females (N = 37)
Don't Know About Any	17	27
Classical Mathematicians	63	51
Current Professors	20	22
	100	100

Table D-10

Previous Majors Held by Undergraduate
Math Majors

	Males (N = 43)	Females (N = 49)
None	51	47
Science	35	20
Liberal Arts	5	27
Double Major	9	6
	100	100

Table D-11

Undergraduate Responses to: "Do you Know of Any Special Efforts Being Made by Your Department on the Behalf of Female Students?"

	Males (N = 40)	Females (N = 40)
Yes	10	8
No	90	92
	100	100

Table D-12

Undergraduate Responses to: "Is it Important for Professors to Take Special Interest in Students?"

	Males (N = 43)	Females (N = 38)
Yes	72	90
No	5	5
Yes, but it Depends on the Situation.	23	5
	100	100

Table D-13

Distribution of Undergraduate Students Who Have Had Female College Professors

	Males (N = 42)	Females (N = 46)
Yes	55	63
No	45	37
	100	100

Are There Any Differences Between Male and Female College Professors?

	Males (N = 23)	Females (N = 34)
Yes	48	65
No	52	35
	100	100

Table D-14

Undergraduate Responses to: "Is the Person You Designated as the one With the Qualities you Most Admire a Role Model for you?"

	Males (N = 40)	**Females** (N = 45)
Yes	50	56
No	35	37
No Role Models	15	7
	100	100

Table D-15

Undergraduate Responses to: "In Retrospect, is There Someone You Had Been Influenced by Even Though You Were Not Aware of it at the Time?"

	Males (N = 42)	Females (N = 48)
No One	10	19
High School Teacher	24	25
Family Member	14	17
Male Friend	28	4
Female Friend	2	6
Someone, but Can't Specify	10	2
Boyfriend/ Girlfriend	0	15
Professor	10	0
Other	2	12
	100	100

Table D-16

Undergraduates' Plans for Graduate School

	Males (N = 39)	Females (N = 50)
Unsure	13	34
Not Going	10	14
Going, but Area Undecided	18	12
Mathematics/ Computer Sci.	31	16
Science	3	0
Economics	5	0
MBA	14	14
Liberal Arts	3	2
Medical School	3	2
Law School	0	2
	100	100

Table D-17

Distribution of Undergraduates Who Aspire to be a Mathematics Professor

	Males (N = 39)	Females (N = 47)
Mathematics Professor	28	15
Other	72	85
	100	100

Table D-18

Distribution of Undergraduates' Projections of Activities Ten Years from Now

	Males (N = 38)	Females (N = 46)
Working Full Time	84	45
Full Time Homemaker	0	21
Full Time in School	0	6
Part Time Work/ Family	0	9
Part Time Work/ School	0	9
Unsure	16	9
	100	100

Table D-19

Distribution of Undergraduate Students
Who Study With Others

	Males (N = 43)	Females (N = 46)
Routinely Study With Others	28	44
Sometimes Study With Others	14	28
Never Study With Others	58	28
	100	100

Table D-20

Distribution of Number of Friends Who Also are Math Majors

	Males (N = 45)	Females (N = 48)
None	49	42
Some (Less than 4)	44	35
Many (Four or more)	7	23
	100	100

Table D-21

Undergraduate Responses to: "Whom Would you Like to be Like?"

	Males (N = 50)	Females (N = 43)
Myself	0	16
No One	26	21
A Math Professor	6	0
Sports Figure	10	5
Entertainment Figure	14	7
Family Member	10	2
Former Teacher	2	0
Political Figure	6	2
Religious Figure	4	0
Famous Mathematician	12	16
Rich and Famous	0	7
Business Person	4	5
Whimsical Activity	2	9
Other	4	10
	100	100

Table D-22

Undergraduates' Racial Characteristics

	Males (N = 43)	Females (N = 48)
White	93	88
Black	5	8
Other	2	4
	100	100

APPENDIX E

SUPPLEMENTARY TABLES FOR GRADUATE STUDENTS

Table E-1

Occupational Background of Graduate Students' Parents

	Father's Occupation		Mother's Occupation	
	Males	Females	Males	Females
	(N = 25)	(N = 14)	(N = 23)	(N = 16)
Physician	8	7	0	0
Business-man	16	29	0	0
Engineer	16	29	0	0
Clergy	8	0	0	0
College Professor	8	14	4	6
Blue Collar	28	7	26*	25*
High School Teacher	0	7	22**	31
Other Professional	12	0	0	0
Farmer	4	7	0	0
Housewife	0	0	44	31
Nurse	0	0	4	7
	100	100	100	100

* 70% clerical/saleswork

** Includes two administrators

Table E-2

Educational Background of Graduate Students' Parents

	Father's Education		Mother's Education	
	Males	Females	Males	Females
	(N = 25)	(N = 14)	(N = 23)	(N = 17)
Less Than High School	16	0	9	12
High School	12	29	26	29
Some College	8	14	23	23
Bachelor's Degree	24	29	26	18
Some Graduate Work	12	7	9	6
Master's Degree	12	21	9	12
Professional Degree	16	0	0	0
	100	100	100	100

Table E-3

Distribution of Academic Honors of Graduate Students

	Undergraduate Honors		Graduate Honors	
	Males (N = 19)	Females (N = 17)	Males (N = 12)	Females (N = 9)
None	5	18	33	78
1	43	23	33	11
2	36	29	16	11
3	11	18	9	0
4	0	6	9	0
5+	5	6	0	0
	100	100	100	100

Table E-4

Distribution of Graduates' First Influence Person for Math

	Males (N = 26)	Females (N = 21)
No One	15	29
Family Member	27	24
Male High School Math Teacher	35	5
Female High School Math Teacher	12	10
Elementary School Teacher	0	19
College Professor	8	10
Other	3	3
	100	100

Table E-5

Distribution of Graduates' Reasons For Particular Graduate School Decision

	Males (N = 47)	Females (N = 22)
Proximity	15	32
Departmental Reputation	32	23
Financial Aid	17	9
Only Department Accepted By	11	5
Recommended by Undergraduate Professor	13	0
Circumstance	0	27
Easy to be Accepted	4	0
Other	8	4
	100	100

Table E-6

Graduate Students' Perceptions of the Importance and Expression of Special Interest Shown to Graduate Students by Professors

	Important		Shown	
	Males (N = 25)	Females (N = 14)	Males (N = 25)	Females (N = 13)
Yes	100	86	76	85
No	0	14	24	15
	100	100	100	100

Table E-7

Distribution of Graduates'
Academic Advisor's Encouragement

	Males (N = 22)	Females (N = 12)
Yes	82	83
No	18	17
	100	100

Table E-8

Distribution of Persons Who Have Influenced Graduate Students Regarding the "Best Way" to do Math

	Males (N = 24)	Females (N = 16)
No One	38	38
Advisor	8	6
Other Professors	38	26
High School Teacher	8	0
Graduate Students	0	6
Classical Mathematicians	4	0
Family Members	0	6
No Best Way	4	6
Others	0	12
	100	100

Table E-9

Graduate Student Perceptions of Best Student in Department

	Males	Females
	(N = 25)	(N = 14)
No One	12	64
Math Too Specialized to Say	34	7
A Male	50	29
A Female	4	0
	100	100

Table E-10

Graduate Student Perceptions of Best Mathematician on Faculty

	Males (N = 32)	Females (N = 14)
No One Best Person	21	29
Male Best Teacher	6	14
Male Best Researcher	6	7
Female Best Teacher	6	0
Female Best Researcher	3	7
Depends on Speciality	21	0
Only Mentions Male	25	29
Only Mentions Female	3	0
All are Best	9	14
	100	100

Table E-11

Distribution of Graduate Students' Perception of the Qualities of a Good Mathematician

	Males (N = 44)	Females (N = 42)
Capacity for Abstraction	9	10
Intuition	5	5
Creative	23	8
Curious	2	0
Analytical	7	7
Intelligent	5	5
Perserverance	18	19
Publish	2	0
Loves Math	2	5
Patience	5	10
Originality	5	0
Sees Aesthetics In Math	5	0
Clarity and Communication	5	7
Concentration	2	2
Attend to Details	5	2

Table E-11

Distribution of Graduate Students' Perception of the Qualities of a Good Mathematician (continued)

	Males (N = 44)	Females (N = 42)
Systematic	0	5
Skill and Knowledge	0	5
Gets Things Done	0	2
Balanced Person	0	2
Nice Personality	0	2
Open Minded	0	2
No Consistent Style	0	2
	101	100

Table E-12

Distribution of Graduate Students' Intent to Study With Particular Faculty

	Males (N = 23)	Females (N = 14)
Yes	26	29
No	61	71
Some Possibilities	13	0
	100	100

Table E-13

Distribution of Graduate Students Who Know Professors in Math Departments Other than Their Own

	Males* (N = 24)	Females (N = 14)
Know Other Professors	54	64
Do Not Know Other Professors	46	36
	100	100

* The distribution between departments were highly skewed. 75% of the students from NOrthwestern and 60% of those from Chicago knew other professors, while only 20% from Circle did. The same pattern holds for the females, with 55% of those from Circle not knowing other professors.

Table E-14

Graduate Students' Perceptions of How Math is Studied

	Males (N = 25)	Females (N = 17)
Mostly Alone	80	75
Sometimes With Others	20	19
Mostly With Others	0	6
	100	100

Table E-15

Graduate Students' Responses to:

"What is Math Intuition?"

	Males (N = 25)	Females (N = 19)
Don't Know	8	5
Educated Guess Based on Experience	25	32
Flash of Insight	8	0
Innate Ability	8	16
"Feel" for Math; Mental Visualization	43	47
Technique	8	0
	100	100

Table E-16

Distribution of Graduate Students' Perceived Differences in Male-Female Math Intuition

	Males (N = 24)	Females (N = 17)
No Difference	58	58
Too Few Females To Tell	21	0
Females Have Less Than Males	4	18
Females Have More Than Males	4	6
Males Have Certain Advantages	13	12
Depends on Type of Math	0	6
	100	100

Table E-17

Distribution of Perceived Importance of Math Intuition by Graduate Students

	Males (N = 21)	Females (N = 14)
Vital	42	29
Important	42	50
Not Important	10	14
Don't Know	6	7
	100	100

Table E-18

Distribution of Graduates' Perceived Differences in Male-Female Undergraduate Math Experiences

	Males (N = 22)	Females (N = 19)
No Difference	55	37
Few Females	22	11
Negative Family Experiences*	14	21
Positive Family Experiences**	9	5
Positive Male Experiences***	0	26
	100	100

* eg., professors flirting with females, uncertainty about role, questioning of ability

** eg., females get more attention, reverse discrimination

*** eg., males have more ability, more aggresive, clearer goals

Table E-19

Distribution of Graduate Students' Perceived Differences in Male and Female Graduate Students

	Males (N = 33)	Females (N = 23)
No Difference	13	17
Too Few Females to Tell	11	0
Females Tend to be Foreign	8	4
Females Not as Good as Males	3	9
Females Drop Out	11	0
Males Aggressive and Confident	5	4
Females More Affective	3	4
Females Family-Oriented	5	13
Males Chauvinistic	8	0
Females Not Assertive	3	4
Females Less Devoted to Pure Math	5	22

Table E-19

Distribution of Graduate Students' Perceived Differences in Male and Female Graduate Students (continued)

	Males (N = 38)	Females (N = 23)
Females Stick Together	5	0
Females Are Loners	2	0
Females Older	0	3
Females Have to Work harder	0	3
Other	2	0
	100	100

Table E-20

Graduate Student Perspectives on Undergraduate Math Majors of the Opposite Sex

	Males (N = 25)	Females (N = 14)
No Difference	16	28
Gender Not Relevant	4	7
Too Few Females to Answer	16	0
Didn't Know Other Sex	8	7
More Males	0	7
Males Better At Math	16	14
Females Better Students	16	7
Males More Confident	0	14
Males More Logical	0	7
Females Too Serious	8	0
Females More Vocal	4	0
Females Neater	0	7
Females Unattractive	12	0
	100	98

Table E-21

Distribution of Graduate Students
Who've Worked With
Female Faculty Member

	Males (N = 20)	Females (N = 16)
No	40	31
Yes, No Problems	20	25
Yes, Some Problems	10	31
Only in Class	30	13
	100	100

Table E-22

Graduate Student Responses to:
"Do Math and Feminity
Go Together?"

	Males (N = 24)	Females (N = 15)
Yes	63	67
Not too much	21	6
No	16	27
	100	100

Table E-24

Graduate Students' Response to: "Are Females as Good in Math as Males?"

	Males (N = 20)	Females (N = 15)
Yes	60	87
No	25	13
Don't Know	15	0
	100	100

Table E-25

Graduate Students' Perceptions of Career Options for Someone With Graduate Training in Mathematics

	Males (N = 51)	Females (N = 30)
Unsure	0	7
Academia	45	20
Industry	39**	53*
Secondary School Teacher	0	17
Government	8	3
Think Tanks	8	0
	100	100

* Circle females constitute 81% of those who designate industry. Only 25% of Circle males make the same designation(**)

Table E-26

Graduate Students' Assessments of Marriage as Part of Their Future

	Males (N = 25)	Females (N = 16)
Already Married	20	38
Not Getting Married	20	6
Marriage With Children	56	31
Unsure	4	25
	100	100

Table E-27

Distribution of Persons Designated by Graduate Students as Influence on Career Choice

	Males (N = 22)	Females (N = 18)
No One	0	17
Myself	44	22
College Professor	23	5
Advisor	5	12
High School Teacher	5	0
Faculty Member	23	22
Graduate Students	0	12
Boyfriend/ Girlfriend	0	5
Friend	0	5
	100	100